DOCUMENT RESUME

ED 276 617 SE 047 614

TITLE	Technological Change to 1991: The Implications for Engineering Technologists and Post-Secondary Institutions. A Report.
INSTITUTION	Thomandale Management, Ltd. (Alberta).
SPONS AGENCY	Alberta Society of Engineering Technologists, Edmonton.
PUB DATE	Jul 86
NOTE	114p.
PUB TYPE	Reports - Research/Technical (143) -- Information Analyses (070) -- Tests/Evaluation Instruments (160)
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	*Careers; *Education Work Relationship; Employment Opportunities; *Engineering Education; *Engineering Technology; *Engineers; Foreign Countries; Interviews; Science and Society; Technological Advancement; *Trend Analysis
IDENTIFIERS	*Canada

ABSTRACT

This study was designed to identify and to evaluate technological changes affecting the careers of the members of the Alberta Society of Engineering Technologists (ASET) at present and up to 1991. Efforts were directed toward identifying those variables affecting employment and recommending courses of action to help technologists remain current. Interviews were conducted and questionnaires were distributed for the purposes of obtaining ideas on the state of technology and on trends that might affect engineering technology. These findings and other contents of the report include: (1) a review of the literature on technology in Canada including a three-page list of references; (2) interviews (discussing the perspectives of individuals from corporations, governmental organizations, and educational institutions on selected issues related to Canada's high technology industry); (3) a technologist's perspective (reporting questionnaire results from ASET members); (4) summary (listing the major findings and highlighting implications for technologists and institutions); and (5) recommendations (providing comments to ASET members and postsecondary institutions and identifying issues for further analysis). Appendices consist of the study objectives, the persons interviewed and the interview outline, the questionnaire, and an explanation of the Center for Advanced Technology Education (CATE). (ML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED276617

TECHNOLOGICAL CHANGE TO 1991: THE IMPLICATIONS FOR ENGINEERING TECHNOLOGISTS AND POST-SECONDARY INSTITUTIONS

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Brian McCormack

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE 042 614

BEST COPY AVAILABLE

TECHNOLOGICAL CHANGE TO 1991: THE IMPLICATIONS FOR ENGINEERING TECHNOLOGISTS AND POST-SECONDARY INSTITUTIONS

A REPORT PREPARED FOR THE

ALBERTA SOCIETY OF ENGINEERING TECHNOLOGISTS (ASET)

BY

THOMANDALE MANAGEMENT LTD.

JULY, 1986

BEST COPY AVAILABLE

TABLE OF CONTENTS

		Page
ACKNOWLEDGEMENTS		
EXECUTIVE SUMMARY	.....	i
INTRODUCTION	.....	1
	Methodology and Context	2
PART 1	TECHNOLOGY IN CANADA: A REVIEW OF THE LITERATURE	1.1
	Emerging Technology	1.1
	Innovation and Diffusion	1.2
	The Canadian Perspective	1.4
PART 2	TECHNOLOGICAL CHANGE: INTERVIEWS WITH INFORMED PERSONS	2.1
	Technological Advances to 1991	2.5
	Specific Technological Innovations and Their Impact	2.7
	Principal Work Functions	2.15
	Engineering Disciplines	2.23
	Skills Required by Technologists	2.24
	Qualifications of Technology Graduates: The Gaps	2.30
	Experienced Technologists - The Gaps	2.32
	Training	2.33
	Preparing Technologists - Actions By Institutions	2.35

TABLE OF CONTENTS

		Page
PART 3	THE TECHNOLOGIST'S PERSPECTIVE	3.1
PART 4	SUMMARY AND MAJOR FINDINGS	4.1
PART 5	RECOMMENDATIONS AND IMPLICATIONS	5.1
	Recommendations for ASET Members	5.1
	Implications for Post-Secondary Educational Institutions	5.3
	Issues for Further Analysis	5.5
	Concluding Comment	5.6

APPENDICES

A. DETAILED OBJECTIVES OF THE STUDY

B. LIST OF ALBERTA INTERVIEWS
LIST OF EASTERN CANADA INTERVIEWS

C. STRUCTURED INTERVIEW OUTLINE

D. ASET MEMBER QUESTIONNAIRE

E. AN INTRODUCTION TO CATE

ACKNOWLEDGEMENTS

A number of people have contributed significantly to this study and I would like to fully acknowledge their role in addressing the central issues.

First, there are the many people – listed separately in Appendix B – who agreed to be interviewed and who took the time both to prepare for the interview and to comment in depth. Their observations are central to this study.

Similarly, I am grateful to the members of the Technical Advisory Committee for their thoughtful and helpful guidance throughout the project. The members of the committee were as follows;

- Dr. E.J. Wiggins, P.Eng.
  Chairman

- Dr. James Dunn
  Faculty of Business
  University of Alberta

- Mr. William Glanville
  Chairman, Civil and Architectural Technologies
  Northern Alberta Institute of Technology

- Mr. Rupert Hooper, P.Eng.
  Supervising Engineer
  Pipeline Engineering (Design)
  Nova, An Alberta Corporation

- Mr. John Kienholz, C.E.T.
  Engineering Technologist
  Alberta Agriculture

- Mr. Brian McCormack, C.E.T.
  Executive Director
  Alberta Society of Engineering Technologists

- Mr. Don Smith, C.E.T.
  Associate Registrar
  Alberta Society of Engineering Technologists

- Dr. A. Vanterpool
  Assistant Deputy Minister
  Technology Research and Telecommunications
  Government of Alberta

I would like to fully acknowledge the financial assistance provided by Employment and Immigration Canada, in jointly funding the study with ASET. Mr. Dave Simmons, Labour Market Development Branch, provided the departmental liaison. His support has been much appreciated.

Finally, I must acknowledge the assistance of my associate, Marilyn Turner. Ms. Turner's contributions have been timely, well reasoned and significant.

Thomas G. Nisbet
President
THOMANDALE MANAGEMENT LTD.

BEST COPY AVAILABLE

EXECUTIVE SUMMARY

INTRODUCTION

The major purpose of this study is to identify and evaluate those technological changes affecting the careers of the members of the Alberta Society of Engineering Technologists (ASET) from the present to 1991. The study objectives were directed towards identifying those factors affecting employment, recommending courses of action to help technologists remain current, and pinpointing trends in demand for technological skills. The forecast period was restricted to five years for two reasons. First, five years is a short enough time for projections to be reasonably accurate and, second, it is long enough to allow for corrective action.

To date, little has been written about technological change and its impact on that section of the work force under scrutiny – the engineering technologist. Where it exists, the most current information about the emerging technologies is in speeches, in media articles and in often unpublished reports by analysts, policy makers and similar professionals. Work published in the early 1980s tends to be outdated already.

Consequently, the focus of this study shifted towards that small group of people in Canada who are working with or writing about the new technologies because technology is their business. A number of such informed persons were interviewed for their ideas on the state of technology and on trends that might affect engineering technologists. Three groups were represented in the study.

- Private and public corporations using or producing high technology

equipment (e.g., Northern Telecom; Dow Chemical Canada Inc.; Nova, An Alberta Corporation).

- Government organizations and departments (federal, provincial and municipal) either using high technology equipment or involved in the research and administration of technology-related projects, programs and studies (e.g., Economic Council of Canada, City of Edmonton Water and Sanitation Department, Alberta Research Council).

- Educational institutions involved in the education and training of technologists (e.g., Ryerson Polytechnical Institute, DeVry Institute of Technology, Northern Alberta Institute of Technology, Southern Alberta Institute of Technology).

The interviews were conducted in eastern Canada and Alberta between January and May 1986. A total of 63 people were interviewed, 38 of whom were located in Alberta. A number of these presented an industry perspective. Many of the organizations represented in the interviews were also major employers of technologists. Those interviewed in Alberta together employed some 1500 technologists.

MAJOR FINDINGS

The major findings of the interviews are as follows:

- over the next five years, microelectronics applications will be linked to the greatest number of changes with developments predicted to proceed in an extrapolation of what now exists;

- technological changes are expected to be evolutionary and incremental, occurring most often in concert with other changes such as those in work organization;

- the major trend is towards technological change of an inter-related nature with innovations becoming increasingly interdependent; change will not often occur in isolation.

- emanating from this trend is an increased demand for knowledge in related disciplines (such as electronics and mechanical) and an increased demand for a knowledge of the relationship between the components of an integrated system (a systems approach).

- the challenge of technologists will be to see and understand the whole system and to keep that system operating effectively, with the role of the troubleshooter becoming an important one;

- computer literacy is stressed not so much for its own sake as in the context of the systems approach but as a means to understanding logic;

- as the workplace changes in response to new technology so does the method of tackling work: team projects and quality work circles are predicted to become prevalent;

- success in such a work milieu will depend on the technologist's possessing a flexible attitude and strong interpersonal and communication skills; technologists will have to be able to work across discipline lines and across organizational lines.

- leading technologists will also have a sense of the "bigger picture" of business, including a basic knowledge of finance, economics and marketing;

- the nature of work and work functions is changing so substantially that the "technological life expectancy" of a new graduate is as little as five years.

- continuous learning is becoming a reality since the technologist may be required to "re-tool" three or four times in his working life to keep abreast of the changing technologies.

While the major portion of the study was directed to those most involved in the decision making of technological change, it was felt important to get some feedback from ASET members on their experiences and expectations. In January 1986 a questionnaire was sent to ten chapters of ASET in Alberta and the Yukon Territories. Their responses lend support to the comments in the interviews.

Based on the major findings from the interviews, a number of recommendations were made for ASET members and implications outlined for institutions involved in the education and training of technologists in Alberta.

RECOMMENDATIONS FOR ASET MEMBERS

These issues identified in this study are critical to ongoing employability. They may well mean the difference between being hired or not being hired, being promoted or being passed over, being kept on or being laid off.

- Assume full responsibility for your career development, for assessing change and adapting accordingly. The person who relies on the government, the institutions or his employer to keep him current may find himself out of date.

- Examine your present job critically because the product or process on which you are working could be eclipsed by new technology. Keep up to date in your field. The need for continuous learning is a reality.

- Examine the disciplines related to your discipline and take steps to acquire more knowledge here. Your value to your employer and your marketability will improve significantly. Cross reference your analysis with the comments on job functions.

- Improve your communications skills (written and oral) and your interpersonal skills. Your promotability and progress depends very heavily on these skills - skills that will help you work across discipline boundaries and organizational lines.

- Be aware of the importance that employers place on motivation, enthusiasm, creativity and hard work. These attributes help neutralize deficiencies in other areas and improve your resistance to layoff.

- Acquire or expand your knowledge of microelectronic applications to your field of work.

IMPLICATIONS FOR POST SECONDARY INSTITUTIONS

The implications from the findings of this study indicate the following courses of action by education institutions:

- improve responsiveness to the needs of employers through such means as more effective advisory committees, expansion of continuing education programs, and co-operative student programs

and the establishment of centres of excellence for post-diploma study.

- increase the priority on teaching communication skills and interpersonal skills; these are critical to the mobility and promotability of the graduates.

- critically examine the preparedness of graduates for the workplace, particularly in terms of life and work skills, business/industry orientation and a knowledge of the learning process - "learning how to learn".

- investigate the options for increasing the teaching of interdisciplinary technical skills keeping in mind the appropriateness and marketability of the mix;

- investigate the feasibility of more systems orientation in the teaching of the engineering technology disciplines.

- foster a basic understanding of microelectronics, systems and applications in all disciplines;

- verify respondents' perceptions that the high growth disciplines will be electronics technology, communications technology, instrumentation technology and computer technology, and make appropriate adjustments.

Other subjects suggested for follow up by the institutions include a market analysis by discipline and an evaluation of the potential for an expanded continuing education program. Finally, the development of a comprehensive marketing strategy is indicated in order to cope

successfully with a more competitive market for instruction, the prospect of declining enrollment and tighter government funding.

This study has focussed on a relatively new area of technological change - the impact of change on the technologist. While specific technological innovations will continue to affect the technologist, it is the impact of these changes in combination together with changes in the way work is performed that will have the biggest impact. The implications for both the technologists and the institutions are far reaching. While both ASET members and the institutions have been addressing many of the issues - and in that sense they are not entirely new - the evidence suggests that not nearly enough is being done or that what is being done is not as effective as it might be. Both groups should consider the recommendations in this context.

INTRODUCTION

The Alberta Society of Engineering Technologists (ASET) is the professional association which evaluates and accredits the credentials of those technicians and technologists who wish to become certified in Alberta. In addition, ASET speaks and acts on behalf of its 5600 members who represent the engineering, geophysical and geological disciplines.

In 1985, the governing body of ASET became concerned about the impact of the new technologies on its members. Central to this concern was the answer to what changes were occurring in the workplace and how ASET members might be advised to respond to those changes, both immediately and in the longer term. ASET wanted to find out what skills are required by technologists and what new demands are being imposed on them vis-à-vis technological developments.

A seven member technical advisory committee was set up to work with the author in establishing the terms of reference of this study. Throughout the course of the study, monthly meetings were held to assess the direction of the work in progress.

The major purpose of this study is to identify and evaluate those technological changes affecting the careers of the members of the ASET from the present to 1991. The study objectives were directed towards identifying those factors affecting employment, recommending courses of action to help technologists remain current, and pinpointing trends in demand for technological skills. The forecast period was restricted to five years for two reasons. First, five years is a short enough time for projections to be reasonably accurate and, second, it is long enough

to allow for corrective action.

METHODOLOGY AND CONTEXT

A search of the literature revealed that the most current information about the emerging technologies is found in speeches, media articles and in often unpublished reports by analysts, policy makers and similar professionals. The major part of this study, therefore, is comprised of comments by these people in that they are most knowledgeable about technology in Canada, generally, and in Alberta specifically. In some cases these people are acknowledged experts. The people selected to be interviewed were chosen because they are conducting research into technology and its implications, because they represent a company or institution which is using technology innovatively either as a process or to produce a good, or because they represent institutions which are training technologists. When being interviewed, these people were asked to focus on what is here and what is coming. No attempt was made to investigate the research and development stages of existing technology. Similarly, no attempt was made to determine quantitatively the supply and demand for technologists.

It must be pointed out that, almost without exception, respondents gave thoughtful and deliberate consideration to the questions raised in the structured interview. For this reason, their comments in Part 2 stand alone. Like remarks have been grouped and compiled under appropriate headings, and, where fitting, direct quotes have been included for emphasis or illustration.

Similarly, it must be noted that many of the persons interviewed were specialists and, consequently, were neither prepared nor able to

comment on every question. Experts in communications cannot be expected to be aware of innovations using high pressure fluids. Many of the comments recorded here are, therefore, sector-specific and presented from the sometimes limited perspective of the expert. This is both a strength and weakness of the report. The comments here are authoritative and current; however, within the scope of this project, they are not intended to present the whole picture of any particular industry or technology. This might well be the subject of further study or validation. The information upon which the main ASET member recommendations are based, however, requires no further validation. The information is the most current available and comes from the most authoritative sources.

The interviews were conducted in Eastern Canada and Alberta between January and May, 1986. Interviews were structured around a questionnaire (see Appendix C) sent to interviewees beforehand. The interview lasted about one hour, during which time the interviewer raised each question and recorded the answers. In some of the interviews, more than one person participated, and in one session, a group of six participated. All comments from these sessions have been considered in this report. A total of 63 people were interviewed, 38 of whom were located in Alberta. (A list of interviewees is included in Appendix B.)

While the basic thrust of the project was to direct available resources to the principal authorities and decision makers involved in technological change, it was also felt that some feedback from ASET members was important. Consequently it was decided to utilize the chapter organization within ASET to obtain this information. A questionnaire was designed and in January 1986 sent to the ten chapters of ASET in

Alberta and the Yukon Territories. Designations used for the engineering technology disciplines and work functions were borrowed from the Employment and Immigration Job Scan Survey. A letter explaining the purpose of the study and outlining instructions for completing the questionnaire was read to members by the Chapter President at a subsequent meeting. Members were given 15 minutes to complete the questionnaire. A total of 159 members completed a questionnaire, representing four percent of ASET membership.

This study was undertaken in a period of dramatic change. In the last quarter of 1985, optimism about Alberta's economic outlook grew, but by the spring of 1986 oil prices had fallen drastically. In the agricultural sector, recurring problems brought about by several years of drought, insect infestations and depressed world prices defy short-term resolution. Alberta is diversifying its industry and some sectors predict a more favourable year. However, domination by the resource-based industries of petroleum and agriculture - which are arguably the most depressed - means this province's economic outlook will remain cloudy in the short term at least.

It was within this context that interviews reported in this study took place. The mood of the time is reflected in responses, particularly in those of the Alberta interviewees. So, despite the reminder that the study focus was on structural change and not necessarily numbers of jobs, many respondents qualified their statements with economic references. Respondents themselves made the link between economic and technological change. In fact, when asked to choose between economy and technology, ASET members more often pointed to economic factors as having influenced their careers.

PART 1 TECHNOLOGY IN CANADA: A REVIEW OF THE LITERATURE

EMERGING TECHNOLOGY

Before attempting to predict what will occur in the future, one must have a clear snapshot of what is happening now. It is essential to know what new technology is being introduced in the workplace, and whether technologists are meeting the changing demands brought about by that new technology. Such a picture, clearly delineated in black and white, is not available. Instead a mosaic emerges, a composite of facts, deductions, and cautious speculations. The most current information about the emerging technologies is found in speeches, in media articles, and in often unpublished reports by analysts, policy makers and similar professionals. Up-to-date and authoritative information is best obtained through discussions with these people, with employers and graduate technologists.

A review of the literature shows that work published in the early 1980s already tends to be outdated. Indeed, a number of today's technologies - fibre optics, photovoltaics, molecular biology - were confined to research laboratories or known to only the inside few even five years ago. In a recent speech to the Canadian Business Equipment Manufacturers' Association, Arthur Cordell, science advisor to the Science Council of Canada made this point emphatically. "New industries and job descriptions which only 20 years ago were either unheard of or were to be found in the works of writers of science fiction are now part of our daily life." Mr. Cordell describes microelectronics, fibre optics, digital networks and the coaxial cable system as the "new transforming technologies that are having an effect

on society and the economy similar to the impact of electricity, the automobile and the telephone in an earlier stage of development."[1]

The widespread diffusion of the microprocessor some twelve years ago brought technological change to industry and individuals alike. In the last five years, changes have occurred more rapidly prompting reference to a "microelectronic revolution" which is affecting the world as dramatically as did the industrial revolution of 200 years ago.

INNOVATION AND DIFFUSION

Emanating from a 1982 international summit meeting on science and technology, a federal government report identifies three central aspects to the role of technology in the economy.

- technological change - which is the acquisition of new knowledge about methods to produce goods and services;

- innovation - which is the introduction of these methods into the regular system of production of goods and services and;

- diffusion - which refers to the widespread adoption, purchase and the use of new techniques or products.[2]

A 1982 report by the Organization for Economic Co-operation and Development outlined the processes of innovation and diffusion. The first step is invention or technical development which often takes place in industrial laboratories and leads to a functioning prototype. The second step is the application of this new product or process. This is

the innovative or pilot stage usually taken on by leading-edge companies and closely monitored by other interested companies in the same industry. The first adopters play a strategic role in determining the speed and direction for subsequent diffusion. If the leaders are successful in applying the new technology, it will soon be diffused to companies in a second group - those more technically and financially advanced than their competitors. From this group the technology will be successively adopted by a third, fourth, and 'nth' group of companies throughout the industry as a whole.[3]

Innovation is market driven. Undertaken by firms in the course of doing business, innovation is an ongoing process and does not result in a technical advancement or invention without commercial application. But marketing or diffusion can only become possible once the manufacturing has been proven technically viable. Consequently the steps in the innovation and diffusion processes are inextricably interdependent.[4]

Diffusion of a new manufacturing process to potential user firms can be protracted. Lags of 20 to 25 years between first and last adopters are not uncommon. An Economic Council of Canada study on innovation in five industries shows that new processes are usually developed abroad with the average lag for their first adoption by Canadian firms being nine years. New products are introduced seven years after their development.[5]

THE CANADIAN PERSPECTIVE

Canada's Resource Industries

Historically, Canada has been a rich country and one whose citizens have enjoyed a high standard of living, but it is a standard which has been achieved and maintained through the development of natural resources. Today Canada faces a crisis. Her stock of resources is diminishing while the competition for the production of raw materials is increasing. It is speculated that the world market for some crude and fabricated materials will remain weak for some years because of new manufacturing methods and a reduction in the use of steel for car parts.[6] Resource industries, because they are not labour intensive, will have to become increasingly automated to compete in world markets. (This, of course, has particular relevance for Alberta industries.)

Canada's Competitiveness

In the forefront of the technological revolution are those countries which are adapting their industrial structure to gain a larger share of the market in processed or value-added products. Between 1968 and 1983, value-added products, such as high and medium technology products and motor vehicles and parts, accounted for 60 percent of Canada's imports while only 35 percent of Canadian exports fell into these categories.[7] With the rise of the newly industrialized nations (Brazil, South Korea, Taiwan and Singapore), Canada's share of the competitive market for manufacturing goods is shrinking. According to an executive of Honeywell Ltd., Canada has been losing a share of world trade "faster than any other industrialized nation."[8]

Currently, Canada has a trade deficit of twelve billion dollars in high technology goods. This deficit is concentrated in four categories which account for eight billion dollars: scientific and professional instruments (80 percent imported), machinery and transportation equipment (70 percent imported), and electrical products (40 percent imported). While Canada appears to have the prerequisites for claiming a larger portion of the world's production of value-added items, this country continues to lose ground in the technological race. There is every indication that this loss is due to a slower rate of technological innovation and diffusion.[9]

Canada's competitiveness depends, in part, on its rate of adoption of innovations relative to the rates of other countries. While few researchers have systematically examined how Canada fares in this regard, one study undertaken in the 1970s compared international adoption of new processes in the pulp and paper industry, the textile industry and the tool and die industry. The results indicated that diffusion was slower in Canada than in the United States or European countries.[10] This conclusion, shared by other studies, has led the recent Macdonald Commission to report, "The leading investigators in the field have concluded that new technologies spread more slowly within Canadian manufacturing industries than in other countries."[11]

Canada Lags in Adopting Technological Change

So, despite the international technological revolution, those Canadian industries introducing technological change are doing so only gradually and cautiously. In an article entitled, "Canada adjusts too slowly to technological advances" a Globe and Mail columnist warns, "the country's industrial future is being compromised by the slow and

reluctant pace at which advanced technology is being adopted by Canadian industry."[12] Evidence of this trend can be found in Alberta. An Alberta architectural firm which has recently introduced computer-aided design (CAD) into its organization became interested in CAD some six to eight years ago, but decided that "the industry was not mature enough" to introduce the technology earlier.[13] And, while in the past two years, technology transfer centres have been established in the province, experts report little progress in moving Alberta technology from the drawing board into job-creating production.[14]

While a few companies have "responded successfully to the challenge of world technological competition - in such industries as communications, aerospace, petrochemicals and steelmaking - (these) are the conspicuous exceptions...." In its application of state-of-the-art technology, Canadian industry lags behind its international competitors by as much as nine years.[15] Canada's output of technology amounts to less than one percent of the world's total.[16] The Macdonald Commission reports that a 1984 survey of 28 countries ranked Canada first in natural endowments but seventh in overall competitiveness behind the United States, Switzerland, Japan, Germany, Denmark and Sweden.[17]

Further evidence of this slow rate of diffusion is reflected in the adoption and use of robotics in the Canadian manufacturing industry. Where the number of robots per 10,000 employees was used as an indicator, Canada with 3.7 ranked ninth behind Japan (32.1), Sweden (20.2), West Germany and Czechoslovakia (7.2), France (6.9), Belgium (5.9) and the United States (4.7).[18] In the midst of a world-wide

technological revolution, there is every indication that Canada is not keeping pace.

Reasons for Canada's Slow Rate

What has brought Canada to this trailing position? There are a number of factors which might explain why technological innovation and diffusion have moved at such a slow rate in Canada. These include: market size and competition, company size, the extent of foreign ownership, government policy, the economic environment, and a large and more nebulous group of "other" factors such as labour and societal attitudes and expectations and education. Each of these factors will be examined individually.

Market Size and Competition

Small market size has been cited as a reason for the lack of Canadian innovation. The fore-running countries in the technology race - Japan, the United States, and European Economic Community members - all sell to a market that is from four to ten times bigger than Canada's. This country is one of the few industrialized nations which does not have access to a market of 100 million people and therefore cannot build industrial plants for world-scale production and competition.[19] Where countries do have access to large foreign markets, domestic firms can afford to expand into research and development and spread these costs over a larger sales volume.[20]

Firm Size

Most of Canada's firms are small, with sales of less than one billion

dollars a year. In 1979, Canada had only 19 of the 500 largest industrial corporations in the world. Only two of these could be considered high technology: Northern Telecom and Canada Development Corporation. By comparison, the United States had more than 60 companies in this category.[21]

While small firms play a part in the innovation and diffusion process, their relative success has been in the innovation stages. In the fast moving world of microelectronics the major innovations have often come from these smaller firms. Gandalf Data and AES have become major actors almost overnight.[22] The penetration of new technology into industry depends to a large extent on the risk-taking capacity of firms: those that innovate and those that diffuse. Companies considering introducing new technology will try to reduce their risk by gathering information about the technology, or observing it in situ elsewhere. The larger the company and the more extensive its connections, the more likely it is to have access to this information. Small firms do not have the resources to monitor developments on a world-wide scale.[23]

At the same time, a firm must necessarily weigh the economic advantages of discarding outdated equipment which contributes to short term profit. Large firms tend to adopt new technology faster than do small ones because of their greater financial capacity; their greater ability to monitor, access and adapt new developments; and their greater need to replace equipment.[24]

Furthermore, because of their relative lack of resources, small companies cannot maintain large R and D departments which are necessary to generate and exploit new technologies. Nor can they tolerate the long lead times from basic research to industrial

application. The National Research Council reports that in the production of high and medium technology goods, a typical company takes about ten years to recover its initial investment from the start-up phase and become profitable.[25] Research is expensive. The vice-president of an Alberta-owned biotechnology company says, "if we stopped research, we'd be profitable today."[26] That company, with a staff of 34, has received seven million dollars in assistance from the Alberta government. Many such small research-intensive companies cannot survive without government aid, yet Canada is ninth among industrialized countries in the amount spent on research and development.[27] In many cases, therefore, the introduction or production of new technology becomes the prerogative of the large and financially secure company.

So, while some small companies are responsible for the innovation of new technology, Canada lacks the large firms - those which bring about the wide-spread commercialization and distribution of these innovations and, thereby, the rapid diffusion of technology. One of the reasons that Canada is trailing in the technology race is due to the structural make-up of the nation's firms.

Foreign Ownership

The level of foreign ownership in Canadian industry is extremely high in industries such as pharmaceuticals, office and store machinery, and electrical industrial equipment. Historically, foreign-owned firms have tended to undertake less R and D in Canada than in their head offices, and as a result, are less likely to innovate here. Similarly, where foreign-owned firms have fewer links with Canadian suppliers, the diffusion of technology may be inhibited. A Science Council of Canada

report suggests that because foreign-owned firms obtain supplies outside Canada they tend to place fewer demands on Canadian suppliers for products requiring the most current technological capabilities. As a result, foreign companies have less incentive to assist in developing and updating the expertise of Canadian suppliers. The Science Council sees this trend as significant in explaining why the rate of diffusion remains slower in Canada than in other advanced industrialized countries.[28]

At the same time, foreign firms often possess the technology and skills not provided by domestic companies, and they speed the diffusion of new foreign technologies to Canada through intracorporate transfers. IBM (Canada), for example, makes a positive contribution to our high technology industry and, through its highly competitive nature, helps to diffuse new applications and equipment rapidly through the economy.[29]

The foreign ownership issue is a contentious one, and there is by no means agreement on its effect on Canada's position. Echoing the Science Council's position, the Canadian Advanced Technology Association (CATA) maintains that "foreign ownership in the high-tech sector appears to account for Canada's large deficit in high-tech."[30] But, the Canadian Business Equipment Manufacturers' Association (CBEMA) and others disagree. As CBEMA so correctly points out, many Canadian-made high-technology products contain parts that are imported. The twelve billion dollar deficit is not a function of ownership CBEMA says, but rather a reflection of the fact that Canada is competing with many low-cost manufacturers. The question of foreign ownership and technology is an important one, and more information on this subject is expected to surface as the talks on trade progress. (i.e., between Canada and the U.S. and multilaterally in a

new round of negotiations under the General Agreement on Tariffs and Trade.)

Government Policy

Government policies, particularly those of the federal government, have been criticized as presenting barriers to the innovation and diffusion of technology in Canada. For example, it has been argued that, while most of the innovative work is being produced by the private sector, effective programs do not exist to assist the potential innovator who needs capital in hand rather than tax incentives to get an idea off the drawing board. Another line of criticism is directed towards the unbalanced approach government has taken, an approach that has impaired technological change. Heavy focus has been on incentives and R and D, less has been on the "latter and generally more costly stages of applying new inventions successfully and diffusing these applications quickly and widely enough through the economy." Those in the technology industry believe that government's response to technological change has been neither quick nor concerted enough. By contrast, the Small Business Innovation Research program in the United States has been designed specifically to promote technological innovation within small firms. In Canada it is said that competing and conflicting goals in areas such as regional investment and energy have had an adverse impact on technological change.[31]

In addition to funds not being forthcoming at a stage when they are most needed, present government regulatory policies act as a disincentive to the entrepreneur. One industry may be regulated by, or indeed taxed by, three levels of government. Inefficiency and the resulting adversarial relationship between governments and the private sector could be reduced by policies which lead to "harmonized

regulation with enough teeth to ensure respect of the public interest coupled with built-in restraint to continue to encourage entrepreneurial activity."[32]

Hugh Planche, former Minister of Economic Development, recognized this barrier to innovation and diffusion when, in a recent speech to the Edmonton Council for Advanced Technology he said,

> from the public's point of view, we are advised that the government is difficult and confusing to access for assistance. We must consider creating a single focal point or 'one window' to the government which would streamline access to present and future programs in the science and technology areas.[33]

The lack of co-ordination between governments which is evident in regulation, taxation and funding policies likewise applies to development objectives. Projects may fall prey to a conflict of planning or objectives between the federal and provincial governments. There is no national science policy or broad industrial strategy which might serve to stimulate the technology industry. Such a policy might help to focus attention on the significance of technology and lead to improvements in science education and the creation of stronger links between university and industry.

Hugh Planche goes on to say,

> we must challenge our entrepreneurs and augment this challenge with some form of encouragement. Programs such as a government purchasing policy which buys the 'first product' in the new product

development sequence as well as other forms of support will have to be considered.

Mr. Planche's comments appear to reflect what many players in the technology industry have argued for a long time: government has not done enough, it is only now starting to respond to a problem which has been existing for some years, and the response itself is piecemeal and unorganized.

CATA recently put forward a number of suggestions to further the market development of high technology products. The federal government should help market development by providing "export tax credits to Canadian companies that make an effort to sell to foreign markets. These credits would help offset the prohibitive cost of setting up an export mechanism." CATA members who find competition against the multinationals difficult would like to see the federal government give them "a show of confidence" by buying more products from Canadian high-technology firms. In 1985, the federal government spent four billion dollars on the procurement of advanced technology. CATA questions what portion of this spending went to support the multinationals, and what portion domestic producers.[34]

Other groups call for the lifting of tariffs on computer and telecommunications products (tariffs of 3.9 percent and 17.5 percent respectively), and for a revision of legislation, such as the Canada Patent Act, which presents an obstacle to innovation in the pharmaceutical industry.

Economic Factors

Canada's economic problems over the past decade are well documented and do not have to be re-counted here. However, it does not hurt to reiterate that Canada's resource-based economic sectors swing up and down, and as they do, so do the sectors serving these bases.[35] Given the susceptibility of the resource industry to large uncertainties such as world commodity prices and changing market demands, these fluctuations are expected to continue. The irony is that while Alberta is one of the richest resource centres in the western world, the price of extracting those resources vis-à-vis falling world oil prices makes leaving them untapped the more prudent decision. Alberta has virtually no control over either the demand for petroleum products nor the price that can be placed on them. The United States, on the other hand, through its development of extensive military and space programs, has been able to create and control the market for its domestic production of high technology items.

Other Factors

Unlike countries such as Sweden and Japan, Canada does not have the tradition of national consensus building among labour, government and industry.[36] Company-provided training and education are characteristic of well-managed firms in Japan and other advanced countries, but in Canada, companies are often unwilling to invest in training because of the high mobility of their workers. And, while Japanese management creates opportunities to make its workers feel an important part of their company and to welcome technological innovation as being the company's means to success over its competitors, Canadian workers are often threatened by impending technology and the effect it will have on their jobs.

That fear is not always unfounded. The agricultural industry offers evidence of how mechanization can bring about a dramatic decline in employment. As the Macdonald Commission has acknowledged, "it is difficult, if not impossible to prove that the concern about adverse effects of technological change on total employment is groundless."[37]

In 1982, General Motors of Canada Ltd. laid off 4,800 workers. To protect their members from similar job losses, organized labour groups have been known to close ranks. As a result, labour unions and the process of collective bargaining have been cited as presenting a barrier to technological change.

> The aim in such collective agreements is to codify specific conditions and commitments governing both the responsibilities and conduct of business management and those of union workers. In attempting to achieve this end, it is inevitable that collective agreements typically forged and tempered in adversarial cockpits, should become instruments embodying rigidities. These can greatly complicate, slow or even preclude technological change.[38]

Change of any kind is often threatening and can lead to psychological barriers. A public opinion survey measuring trends between winter 1980 and spring 1983 found that 66 percent of those questioned felt that society is relying too heavily on machinery and technology. Sixty-six percent also believed Canada and Canadian companies to be leaders in the high technology industry. About 72 percent thought that automation had a negative effect on employment and personalization, although these attitudes fluctuated. Concern was less acute where people came into direct contact with technology in their occupations.

Those people who said they were able to cope with change were high-income earners, managers and supervisors, professional and technical workers or those with a post-secondary education.[39] Apparently, ignorance or negativism about technology exists amongst Canadian workers and this may be acting as a psychological barrier to technological growth.

In Japan there is little fear of technological unemployment. "One reason for this is the strong competitive ability of the Japanese economy, but other factors such as the low female participation rate in the labour force, a low birth rate and virtually no immigration are very important."[40] Another factor which appears to be fundamental to Japanese security is the strong and unified commitment towards technological development which is inculcated at an early age - a commitment that begins with the teaching of mathematics and sciences.

When student achievements across nations are compared, at international science tests for example, Japanese children frequently rank first. In Japan the average school year is 240 days and the average day, six to eight hours. Japanese vacations are short, absence from school is minimal and parents are held responsible for their child's attendance. By comparison students in Alberta attend school 200 days a year for five hours a day. An article in the American Journal, Engineering Education compares education in the United States to that of its competitor countries:

> Japan, the USSR, France, West and East Germany, and the People's Republic of China all place far greater emphasis than does the U.S. on mathematics and science education. Education in these subjects

> begins in the first grade and continues throughout elementary and secondary schooling, with all students required to take courses in biology, chemistry, physics and earth science, as well as mathematics. The time spent on these subjects, based on class hours, is approximately three times that of a U.S. student who elects four years of mathematics and science in secondary school. Science education is considered so important in the People's Republic of China that policies for it are written into the country's constitution.

The author goes on to ask rhetorically, "is it any wonder that from 1963 to 1977, industrial productivity grew 197 percent in Japan, but only 39 percent in the United States."[41]

While not entirely parallel, Canada's position is very much closer to that of the U.S. than that of the other countries cited. The standard of education in the United States is said to have been declining for some years. What is the situation in Canada? In a recent study on engineering education in Canada, deans of engineering faculties were reported to agree that the quality of students coming from high schools has been steadily increasing; however, "there is considerable concern about the failure of high schools to emphasize technology as compared to pure science and about the quality of the teaching of science and mathematics at the Grade 10 level, when most students start to make their primary career decisions."[42]

How does this observation apply to engineering technologists who have presumably gone through a similar high school curriculum? Are engineering technologists inadequately schooled in the language of technology before they arrive at post-secondary institutions? If so, is

the institution's curriculum substantial enough to fill that gap? Should institutions be emphasizing state-of-the-art technology over basic sciences and mathematics? And, what about communications and the so-called life skills? In short, are graduate engineering technologists adequately prepared to meet the challenge of the emerging technologies? In an attempt to answer these questions, this study will turn to technology specialists, employers and the technologists themselves.

REFERENCES

1. Ronald Anderson, "Canada Adjusts too Slowly to Technological Change", Globe and Mail, June 21, 1985, p.B2.

2. Ministry of State, Economic Development, Science and Technology, Towards 1990: Technology Development for Canada, 1983, p.6.

3. Jan Carlsson and Hakan Selg, "The Promotion of Robotics and CAD/CAM in Sweden," Information Computer Communication Policy, Micro-electronics, Robotics and Jobs, in Organization for Economic Co-operation and Development, Volume 7, 1982, pp.197-233.

4. Kimon Valaskakis, Barriers to the Development of High-Technology Industries: Who is responsible? commissioned for the Canada Tomorrow Conference, November, 1983.

5. Economic Council of Canada, The Bottom Line: Technology, Trade and Income Growth, 1983, p.54 quoted in Economic Transformation: Technological Innovationand Diffusion in Ontario, Ontario Ministry of Treasury and Economics, p.24.

6. Kimon Valaskakis, op. cit.

7. National Research Council of Canada, A Practical Perspective: the NRC Plan 1986-1990, 1985, p.15.

8. Ronald Anderson, op. cit., p.B2.

9. National Research Council, op. cit., p.17.

10. Ministry of Treasury and Economics, Government of Ontario, Economic Transformation: Technological Innovation and Diffusion in Ontario, March 1984, p.16.

11. Royal Commission on the Economic Union and Development Prospects for Canada (the Macdonald Commission), "The European Management Forum", quoted in National Research Council op. cit., p.17.

12. Ronald Anderson, op. cit., p.B2.

13. Peter Brewster, "Computer-aided Design Helps Edmonton Firm" Edmonton Journal, November 30, 1985, p.C16.

14. Don Martin, "High-tech needs market priority," Calgary Herald, November 27, 1985.

15. Ronald Anderson, op.cit., P.B2.

16. Government of Ontario Ministry of Treasury and Economics., op. cit., p.14.

17. National Research Council, op. cit., p.17.

18. Ronald Anderson, op. cit., p. B2.

19. Science Council of Canada, op. cit., p.35.

20. Government of Ontario Ministry of Treasury and Economics, op. cit., p.20.

21. Ibid., p.21.

22. Science Council of Canada, Planning Now for an Information Society-Tomorrow is too late, 1982 p.28.

23. National Research Council, op. cit., p.15.

24. Government of Ontario Ministry of Treasury and Economics, op. cit., p.18.

25. National Research Council, op. cit., p.15.

26. Peter Brewster, "City Company Leads the Way," Edmonton Journal, December 27, 1985.

27. National Research Council, op. cit., p.18.

28. Government of Ontario Ministry of Treasury and Economics, op. cit., p.24.

29. Kimon Valaskakis, op. cit. p.11.

30. Karen Howlett, "Industry groups differ on cure for the high-tech trade deficit," Globe and Mail, August 29, 1985.

31. Arthur J.R. Smith, Institutional Barriers to Technical Change, (a paper commissioned for the Canada Tomorrow Conference), November, 1983, p.8.

32. Kimon Valaskakis, op. cit., p.16.

33. Notes from a speech given by the Hon. Hugh Planche to the Members of the Edmonton Council for Advanced Technology, Edmonton, April 16, 1985.

34. Karen Howlett, op. cit.

35. Peter Barnard Associates, Coming to Grips with Change, (A report on the Canadian Consulting Engineering Industry prepared for the Department of Regional Industrial Expansion), February, 1985, p.2.5.

36. Kathryn Warden, "Experts seek ways to build our high tech," Toronto Star, November 26, 1985, p.A1.

37. Ronald Anderson, "Advances in technology may not hurt employment", Globe and Mail, September 10, 1985, p.B2.

38. Arthur A.J. Smith, op. cit., p.10.

39. Richard Anderson, Public Opinion and Technology: Canadians Adjusting to Change, (a paper commissioned for the Canada Tomorrow Conference), November 1983.

40. Kimon Valaskakis, op. cit., p.5.

41. Lawrence P. Grayson, "Leadership or Stagnation?" in Engineering Education, Vol. 73, No. 5, February 1983, pp.356-365.

42. Dominique Mascolo, Peter M. Wright and Gordon R. Slemon, Engineering Education in Canada: Some Facts and Figures, (A discussion paper prepared for the Science Council of Canada), January 198[illegible].

PART 2 TECHNOLOGICAL CHANGE: INTERVIEWS WITH INFORMED PERSONS

INTRODUCTION

There is a small group of people who are in the forefront of the high technology industry in Canada. These people are working with the new technologies and writing about them: technology is their business. A number of such informed persons were interviewed for their views on the state of high technology and on trends that might affect engineering technologists. Three groups were represented in the interviews:

- private and public corporations using or producing high technology equipment (e.g., Northern Telecom; Dow Chemical Canada Inc.; Nova, An Alberta Corporation)

- government organizations and departments (federal, provincial and municipal) either using high technology equipment or involved in the research and administration of technology-related projects, programs and studies (e.g., Economic Council of Canada, City of Edmonton Water and Sanitation Department, Alberta Research Council)

- educational institutions involved in the education and training of technologists (e.g., Ryerson Polytechnical Institute, DeVry Institute of Technology, Northern Alberta Institute of Technology, Southern Alberta Institute of Technology)

A complete list of the interviewees is included in Appendix B. Many of the organizations represented were also major employers of technologists. Those interviewed in Alberta together employed some 1,500 technologists.

ISSUES

The interview was intended to address the following issues (See Appendix C for the detailed outline):

- whether technological change to 1991 is expected to be concentrated in microelectronics, biotechnology and/or materials technology
- actual and anticipated innovations in technologies such as lasers, CAD, computers
- which job functions are expected to increase in demand and/or scope, and why
- which engineering disciplines are expected to increase in demand and/or scope, and why
- which skills (technical, life, work) will be required from technologists
- whether recent technology graduates are adequately trained, or possess the above required skills

- whether experienced technologists possess the required skills
- the state of training and retraining in industry
- what steps educational institutions can take to better prepare technologists

PERSPECTIVES

It must be noted that many of the persons interviewed were specialists and, consequently, were neither prepared nor able to comment on every question. This is true of the questions listing technological innovations and specific work functions. Experts in communications cannot be expected to be aware of innovations using high pressure fluids. Many of the comments recorded here are, therefore, sector-specific and presented from the sometimes limited perspective of the expert. This is both a strength and weakness of the report. The comments here are authoritative and current; however, they are not intended to present the whole picture of any particular industry or technology.

In addition, many of the comments can be seen as being province-specific. Persons interviewed in Eastern Canada, for example, made very few comments about surveying, while their counterparts in Alberta were sometimes unable to respond to the question on robotics.

The comments presented in this section are exclusively those of the people interviewed in this study. While comments are not attributed to

specific individuals because discussions were held in confidence, in some cases direct quotation is recorded for emphasis or illustration, or simply because the comment was so aptly phrased.

CONTEXT

While few environments are ever static, there were a number of significant events occurring during the course of this project which may have had some influence on responses. These events include:

- the oil price dropped to its lowest point in ten years, causing reverberations throughout the oil industry and leading to lay-offs, cut-backs and a plea for government intervention by small companies.

- Finance Minister Michael Wilson tabled his second budget which did not provide a substantial increase in R and D funding. This announcement fell in the shadow of the previous budget which had indicated a commitment to reducing fiscal transfers to the provinces for health and post-secondary education by two billion dollars by 1990.

- a provincial election in Alberta focussed on the depressed state of the petroleum and agriculture industries. Pre-election promises by Premier Getty included commitments to the Husky Heavy Oil Upgrader Project, to Syncrude Canada and to increasing aid to the agricultural industry.

TECHNOLOGICAL ADVANCES TO 1991

Respondents agree that, over the next five years, technological change will occur as a result of advances in microelectronics, biotechnology and materials technology. Of these three, microelectronics will be linked to the greatest number of changes, with developments predicted to proceed gradually in a straight line extrapolation of what exists now. Materials technology will be of secondary importance, and biotechnology will continue to lag behind the other two.

Microelectronics is described as "fuelling the cycle of change," by being the force driving the movement from the production of goods to the production of information – the movement from an industrial to an information society. Microelectronics is described as "affecting not only what we do but how we do it." However, one respondent cautioned that, while this technology may affect the greatest number of people, it has not necessarily had the greatest rate of growth of the three. Growth and development of microelectronics is reflected in industry's orientation towards computerization and instrumentation. Microelectronics has significantly reduced the costs of production and increased the capacity for analysis and problem-solving.

Materials technology in the chemicals industry is seen in the increased use of fibre reinforced plastic vessels, which are light and durable, and in the development of metallic combinations such as titanium with steel. The use of composites in the aircraft industry is growing. In oil sands operations, materials technology will help counteract the effect of sand abrasion on equipment. Materials technology is used to improve

insulation in circuit breakers for the electric power industry and to improve the quality and life of roads and highways. Surface chemistry technology of materials is fundamental to some bio-technology firms dealing with the diagnosis and treatment of disease.

Innovations in biotechnology are described generally as being less easy to identify, and as being more in a state of research and development than are those in microelectronics and materials technology. The impression given by some respondents is that development of technology is lagging, leaving Canada behind her international competitors. In Alberta, firms engaged in biotechnology are growing rapidly, albeit from a small base. Developments in biotechnology were mentioned by Alberta respondents in association with agriculture (livestock embryo transplants), food processing and medicine.

Among the respondents there were some dissenters. One respondent declined to comment saying that emphasis on technological change is faddish and attention should more appropriately be focussed on the fundamentals of science which are less subject to change. Another, representing a specialty chemical company, said that microelectronics could not be used to produce custom-made batch sizes of chemicals because of the discontinuous process involved in this industry.

Generally, over the next five years, technological changes are expected to be evolutionary and incremental, occurring most often in concert with other changes, such as those in work organization. Advances in technology will continue to be interdependent. Typically, innovative equipment will result from a blend of technology, such as

microprocessors or computer systems with conventional mechanisms. The programmable arm on an automated loading machine is one such example.

The trend towards interdependency will result in a demand for technologists with skills in more than one discipline and with the ability to take a "systems approach" towards problem-solving.

SPECIFIC TECHNOLOGICAL INNOVATIONS AND THEIR IMPACT

Interdependency of Innovations

When asked to comment on the recent and anticipated impact of individual technological innovations, respondents were unanimous in citing an increase in the interdependency of innovations. For example, some advances in telecommunications are directly linked to developments in fibre optics; computers are the basis for remote sensing devices. No technological innovation occurs in isolation. The trend is towards change of an interrelated nature, and accompanying this trend is an increased demand for an interdisciplinary and systems approach to work applications. New equipment requires a new combination of information: a robot programmed with a microprocessor will require someone with both mechanical and electronic knowledge to repair it and software knowledge to operate it. In such a case, demand for specialization in mechanical engineering gives way to demand for electro-mechanical and software knowledge.

Because of the interrelated nature of the equipment being used, the tasks associated with the new technologies will require at least a passing knowledge of more than one discipline. Tasks such as analysis, evaluation, maintenance and problem-solving will require a fundamental ability to recognize the relationship between the components of a system and to identify a weak spot, be it electrical, mechanical or communications. The challenge of technologists will be to see and understand the whole system and to keep that system operating effectively. The role of troubleshooter will become an important one. All respondents identified this role despite a trend towards individual components becoming self-diagnostic. In fact, some respondents speculated that a "control system technologist" may come into being.

Alberta respondents volunteered specific examples of disciplinary combinations, including:

- chemical technology and microprocessing for an instrument technologist;
- chemical engineering with a "bio" emphasis and materials technology for a health science technologist;
- electronics technology and civil/mechanical engineering for a water and sanitation technologist;
- civil technology and electrical engineering for a technologist in the power industry.

Robotics

Although prominent in the public eye, the use of robotics should not be viewed as dramatic. When placed in the context of manufacturing, robotics can be seen as simply another piece of industrial equipment, a view which gives a more balanced perspective. The Robotics Industry Association is cautious about making favourable market projections because robotics is presently not a profitable business. The robotics industry is beset by a large number of companies competing for a small market, and the association does not want to attract more competition. Projections showing a rapid growth in the use of robotics should be viewed skeptically. At present, robotics are used for highly repetitive manufacturing tasks, such as spray painting or spot welding, or where safety is a consideration. These markets are presently saturated, and there is a restraint on expansion. The simple and most cost effective applications have already been identified and are in place. The next wave of expansion will depend on the development of more sophisticated sensor devices.

Research into sensor development is slow and painstaking. If the problems are overcome and the technology is developed – and works – there could be tremendous growth. If not, the growth curve will be very different.

Robotics has had limited application in Alberta and, as one respondent indicated, under the present economic conditions, labour is cheaper than this expensive technology. Another respondent noted that as new manufacturing opportunities emerge in this province robotics could be

introduced readily because adjustment factors, such as manpower and equipment replacement, which are characteristic of established industries, will not apply. One sector which could be affected by robotics is mining. Advances in "remote mining" will permit the operator to control the robot at a safe distance from the mine face and eventually from a control room, freeing the miner from the unsafe conditions associated with that industry.

Lasers

Lasers are presently being used in the manufacturing industry to cut metal and fabric, in computer printing, and in medicine for specialized surgery and cancer treatment. Laser usage is described as mushrooming, as lasers find their way into consumer products such as audio and storage disks.

Outstanding research into the use of lasers is being undertaken by the University of Alberta. The recently formed Alberta Laser Institute will provide further impetus in this field.

The laser is a tool which is increasingly being adopted by Alberta industries. One of the developing applications in the province is in welding, where lasers are used to produce a cleaner, quicker and more automated weld. The use of lasers is broadening from welding and cutting into surveying and volume measurement. In agriculture, lasers will be used to sharpen blades on implements such as cultivators and plows. One respondent predicted that through laser use we are moving

towards the "multi-materials shop" where cutting and lamination of metals, wood, plastics, ceramics and stone will be possible. However, the interdisciplinary technology for these new applications is, and will continue to be, in short supply. A possible new discipline is indicated - that of the laser technologist. Such a person might have a range of skills relating to materials, optics, electronics, toxicity (when materials are vapourized) and electric power for heavy duty applications.

CAD/CAM

Traditional drafting is rapidly giving way to Computer Aided Design (CAD). CAD, Computer Aided Manufacturing (CAM), and robotics are integral parts of Computer Integrated Manufacturing (CIM).

While CAM is not prevalent in Alberta, CAD and CADD (Computer Aided Drafting and Design) are. Because of its shorter turnaround time, versatility, lower costs and reduced manpower use, CADD is rapidly being adopted to replace traditional drafting. The traditional draftsman is expected "to go the way of the dinosaur."

Fibre Optics

Four major applications of fibre optics were identified: telecommunications (of voice, image and data), linking process controls, linking of computer work stations, and the development of instruments such as optical sensors. The communications industry has felt the greatest

impact of this technology. The per unit cost of transmitting information using fibre optics is less expensive than that using microwave systems. At the same time, the quality and security of fibre optic transmission is superior to that of satellite. Long distance communication of voice, video and data using fibre optic transmission to link Halifax and Vancou :r is planned for the next decade. Similar transatlantic and transpacific links are imminent.

Fibre optics is being used in rail transportation to link signals and monitor rolling stock. This technology is expected to increase the safety of rail transportation and result in more efficient use of rolling stock.

Computers/Artificial Intelligence

Computers and microprocessors are a pervasive feature of technological development both in industry and in the laboratory. The computer itself "permeates everything," but when the computer is used with other technology such as fibre optics or lasers, its greatest potential is realized. Computers have allowed the individual more time to think and have facilitated the synthesis of vast amounts of data. Computers have led to the development of processes or systems and consequently the emphasis for the technologist is shifting towards process and away from content. One of the technologist's primary functions will be to monitor and maintain the process.

Alberta respondents acknowledged the importance of computers to their

business or industry and expected the influence of computers to continue. Most companies have automated office systems for information storage and production; many respondents mentioned using computers for business, market and/or financial analysis, for contracts, project scheduling and work planning. Computers are being used with satellites to monitor and control the oil and gas pipeline networks and for interoffice transmission of data.

A major company represented in the interviews has 606 computer terminals for 969 employees - and this number does not include terminals used in process control. Computer literacy is crucial for these employees.

One respondent pointed out that, while the change in the technology of sensors (such as thermometers, pressure gauges) and control valves has been incremental, there has been an enormous increase in data analysis and process control since the introduction of computers. The skills which are associated with process control are scarce; however much of the data base management which is presently carried out by engineers could be taken over by technologists.

Artificial Intelligence (A.I.) could be critical, primarily in the area of expert systems, but most Alberta respondents did not foresee an immediate demand for this technology in their particular company. One said, "it is too early to tell how effective A.I. will be." With A.I. more straightforward problem solving and decision making can be put into an expert systems format, thereby reducing the professional's time. In Alberta an A.I. process is being used in seismic analysis and in customized telephone circuitry.

Communications

In Alberta, some companies have aggressively responded to innovations in communications because communications is their business. A number are active in export markets. Others are using communication technology for data and voice transmission between offices or between one central office and outside work stations, an application employed by the oil sands industry. (Fibre optics is fundamental to this linking.) Interoffice telecommunication allows each office quick and equal access to sites and shared data bases. In metropolitan areas, remote camera monitoring is being used to control traffic flow, and telemetry makes the remote measurement of water flows possible for the city of Edmonton Water and Sanitation Department.

High Pressure Fluids

Eastern Canadian interviewees did not comment on high pressure fluids, and Alberta respondents mentioned only that this technology may increase in the next five years because it offers the advantages of providing a clean cut without fumes or sparks and without distortion from heat.

PRINCIPAL WORK FUNCTIONS

Respondents were asked to comment on the potential demand for specific job functions, where demand was defined as importance and scope, and not necessarily a number value. Some of the work functions as described in the questionnaire are not applicable to particular industries, such as oil exploration and production. Some comments are specific to a particular department, so within one company respondents might differ or even contradict each other as each speaks from his own perspective.

Drafting, Design and Design Modification

A majority of respondents expected CAD and CADD to increase in scope at the expense of traditional drafting. Tasks traditionally performed by draftsmen are being taken over by computer graphics or computing machines, with the result being an increase in productivity, quality and sophistication. The demand in future will be for the "electronic version of the draftsman," or that person who has considerably more experience in design than a conventional draftsman but is less qualified than the engineer. The drafting and design combination, which requires greater creativity and flexibility, is being given a higher profile.

Equipment Installation, Maintenance and Servicing, Facilities Inspection

Many predicted that with the introduction of modular and automated equipment, installation services and maintenance functions would increase in scope, but not necessarily in demand for technologists. New technologies have a built-in capacity for self-diagnosis, thereby reducing the demand for manpower. However, the responsibility and range of skills of those technicians who are needed is heightened. One respondent spoke of the stochastic element of the new technologies. Referring to the fact that equipment is less likely to break down, he suggested that, like the Maytag repairman, the technician may not be needed often, but when he was, he had to be able to identify, analyze, and evaluate the problem and react immediately.

Some Alberta respondents agree that there will be a stronger role for technologists in this function, but for a different reason. Now that the price of oil is lower, companies will be forced to concentrate on maintenance and servicing to reduce costs and increase efficiency. One company said that plant operators are sometimes underutilized and in the near future they will have to do more maintenance work to be more cost efficient. In difficult economic times, as capital asset management receives greater priority, equipment installation will decrease, and maintenance and service increase. As equipment ages or reaches obsolescence and has to be replaced, or as a company diversifies its product-line, the technologist wil be required to keep up with the resulting changes, and his role will again increase in scope and importance.

Not all agreed with this analysis, however, suggesting that an increase in remote diagnosis and a trend towards parts replacement over repair would result in a de-skilling. Maintenance would be a case of "plug in and plug out." Monitoring will involve identifying the appropriate flashing light, and repair, replacing the appropriate module. Respondents supporting this perspective predicted a decrease in manpower generally and, specifically, a decrease in the proportion of highly-skilled personnel.

Many felt that facilities inspection increasingly demands a systems approach, particularly as companies become more aware of the production environment. Reference here is to "spacing of machines and understanding exactly what is happening in a production cell," and to understanding the relationship between production cells so as to optimise the use of facilities. To increase efficiency, companies will try to reduce the standing time of equipment, or that time when equipment is functional, but not being used. Such a trend will increase the demand and scope for technologists.

Plant and Industrial Operations

While few respondents chose to comment on the work functions associated with plant and industrial operation, the majority who did predicted an increase in scope and importance for the technologist working here. One respondent suggested a "new breed of technologist" may be required to perform in plant and industrial operations, and he would require a solid knowledge of instrumentation.

Quality Control and Quality Assurance

Most respondents predicted that work functions related to quality control and assurance would increase in scope coincidental with an increase in product competition and customer awareness. More automated methods of quality control - such as Statistical Process Control (SPC) - and more exacting tolerances made possible by precise measurement can be expected to lead to a demand for the higher skills associated with these methods. A minority suggested that, while quality assurance is increasing in importance, preventive action taken at the design stage would result in less after-the-fact inspection. They put forward the argument that Computer Integrated Manufacturing (CIM) methods produce better quality and require less control.

Standards Inspection/Regulatory Investigation

Some respondents expect regulations and standards inspection to increase to reflect a growing public concern over health and safety in the work place. Others said that industry is presently over-regulated and the movement - particularly by the Alberta government - is towards deregulation, which would in turn reduce the scope of this work function.

Process/Product Development

Most respondents agree that competitive pressures will increase the

scope of those work functions associated with process and product development. As the Alberta economy diversifies, and with the resurgence of the entrepreneurial presence, process and product development are bound to increase. (This stance taken by several Alberta respondents reflects their concern with present economic conditions.) Others pointed out that long production runs are giving way to batch-specific runs and to smaller batch sizes. Economies of scope (but not necessarily of scale) will increase due to the flexibility of new manufacturing designs. Design will be more automated and undertaken by fewer and more qualified people.

Surveying

Surveying technology has changed significantly in recent years with the introduction of innovations such as electronic distance measurement (EDM), inertial survey technology, field computers to collect and analyze data on site and Global Positioning Systems (GPS) using satellites. Changes such as these are causing an increase in the scope and importance of surveying, but that increase may be offset by a reduction in the demand for manpower. Respondents in the surveying industry in Alberta said that the scope and importance of this function would either remain the same or increase slightly.

Project Administration, Management

Respondents are evenly divided between predicting an increase in scope

and importance and predicting 'no change' in functions relating to project administration and management. Project administration is expected to become more team oriented, and possibly more bureaucratic as labour, health and safety regulations and controls increase. The technologist will become more involved in production and planning and will participate in team activities, such as quality work circles. Consequently, first class communication and interpersonal skills will be essential. "Good project administrators are difficult to find," was one comment. Some Alberta respondents said only the "star" technologists will be involved in project administration, as this is primarily an engineering function. Others contradicted this stand by pointing out that unlike the engineer the technologist often does not mind "getting his hands dirty," and is therefore better suited to project administration.

Those projecting an increase in management do so on the basis of a movement towards a team approach. Those projecting no increase suggested future managers will come from more generalized backgrounds such as Liberal Arts and Business Administration and the doors of management will be closed to most technologists and engineers.

Research and Development

All respondents predicted an increase in research and development, but their attitude was one of hopeful expectation. The comment was made, "there has to be an increase." Most Alberta firms involved in R and D employed technologists but some said that R and D involves more

engineers and scientists than technologists, and this tendency will continue. It was pointed out that due to recent economic conditions, the oil and gas industry may begin to concentrate more on cost reduction and less on exploration, thereby reducing the need for R and D personnel.

Marketing and Sales

Marketing and sales are expected to increase in scope under the influence of technology. As products become more internationally competitive and technically sophisticated, there will be increased opportunity for technologists to become active in marketing and sales. Furthermore, companies are predicted to move towards product customization as technology makes small batch sizes economical. These trends will result in a demand for skills first in identifying specialized consumer groups, and then in marketing sophisticated products tailored to the needs of these groups. Many respondents felt that all employees should become more aware of the role and importance of the customer.

However, some Alberta respondents argue that technologists are not trained in presentation techniques and, as a result, are not suited to sales. Furthermore their skills are better utilized in concentrating on their technical specialty. In addition, there are many people with university degrees such as Master of Business Administration who are not only more suited, but are also available to take on sales functions.

Education

Most said that education would increase in scope and importance as training and re-training becomes a more continuous process. No distinction was made between those opportunities for training in industry and those in the educational institutions.

ENGINEERING DISCIPLINES

Respondents were asked to comment on the potential demand for specific engineering disciplines where demand was defined as importance and scope and not necessarily a number value. Respondent perceptions were nearly unanimous that high demand disciplines would include instrumentation technology, electronics, communications/ telecommunications technology and computer technology.

There was, however, a lack of consensus with respect to other disciplines. This was largely because many of the respondents (rightly) declined to comment on disciplines beyond their field of knowledge.

SKILLS REQUIRED BY TECHNOLOGISTS

Life Skills

When asked what skills would be required by technologists, many respondents pointed to life skills such as attitude and interpersonal skills, flexibility and the ability to communicate. While not diminishing the importance of technical knowledge, more than one respondent indicated that the technologist will have to have "more than 95 percent grades to be successful in the work milieu." Some said that these life skills would have to be in evidence even as the technologist was being interviewed for employment. Others cautioned that the lack of such skills could prevent the technologist from being promoted.

Attitude and Interpersonal Skills

When talking about the traits which successful technologists must possess, Alberta respondents, particularly, drew attention to the work ethic. Technologists will have to understand the value of work, will have to take the initiative to accomplish the tasks required and not be afraid to "get their hands dirty in the process."

As the workplace changes in response to new technology, so does the method of tackling work. Team projects, quality work circles and project administration are all growing trends which require strong

interpersonal skills. The charge was made that, among technologists and engineers, people sensitivity is "sorely lacking." One respondent suggests, "a hardcore technocrat mentality prevails" which not only makes team participation difficult but, ultimately, can limit the technologist's promotability. Pointing to the need for a change in attitude, another respondent said that technical people must be aware that "this is not a totally male workforce."

Technologists must adapt to changes brought about by economic factors as well as technological factors. In Alberta, since 1982 there have been three sudden changes in the price of oil which have a drastic effect not only on the petroleum industry but also on industries such as consulting engineers, architecture and construction. The technologist working in such industries must adapt his role as megaprojects give way to small projects and specialization yields to interdisciplinary tasks.

Communication Skills

Written and oral communication skills come near to the top of the list of required skills. Verbal communication and interpersonal skills are integral parts of team and project work. To be successful in such work practices, the technologist must be able to convey his ideas effectively - he must be able to present and sell his ideas to a group. Written communication skills are required not only for the daily documentation of work, but also for reports and similar technical correspondence.

"Technological Life Expectancy"

Adaptability and the ability to cope with change were likewise identified as essential characteristics. The nature of work and work functions is changing so substantially that the "technological life expectancy" of a new graduate is as little as five years. After that time, the technologist may well have to begin a gradual retraining, and could possibly have to retrain completely. A complete "re-tooling" may occur three or four times in a technologist's working life, depending on the extent and nature of his initial training and the work undertaken since graduation. "Continuous learning" is predicted to be a reality. A successful technologist will be mindful of technological change and be prepared to undertake skill upgrading or retraining, independently or as provided by his employer.

Accountability

While some respondents believe that colleges or professional associations are responsible for keeping graduates informed of changing technology, others say the onus is on management or the employer. However, most maintain that the responsibility of staying informed rests firmly with the individual technologist. The technologist must look critically at the product or process with which he is working because that product or process may soon be eclipsed by new technology. The technologist is accountable to himself: he must be careful not to "paint himself into a corner."

Technical Skills

Computer literacy is mentioned most frequently as a technical requirement, not for its own sake so much as in the context of the systems approach and as a means to understanding logic. Closely related to computer literacy is the ability to manage, analyze and synthesize information. But, while a knowledge of computers is considered to be a fundamental requirement, it was pointed out that, "we don't need a nation of programmers, we need a nation of problem solvers."

Some respondents identified specific skill requirements. Others emphasized the need for systems and multidisciplinary skills. One saw three skill sets emerging: the first is associated with Computer Integrated Manufacturing (robotics, computer systems, management information systems), the second relates to materials and chemicals – (or those functions associated with the elements in the atomic table), and the third is specific to installation, servicing and maintenance.

Generalized and Specialized Education

The question of required skills also brought out views about the degree to which educational institutions should offer specialized training. Two schools of thought emerged. The first favours a sound education in basic courses such as mathematics, science and communication skills, with some technological specialization. This "generalist" view argues that in a rapidly changing technological environment, a sound basic

education is essential to ensure career mobility and the intellectual flexibility to respond to the demands of an interdisciplinary environment. Educational institutions can not be expected to keep up with a rapidly changing environment. Leading edge technology is often firm specific, uses expensive equipment and requires highly specialized operators. Consequently, educational institutions cannot feasibly teach a wide range of "high-tech" applications. One respondent suggested that knowledge should be the responsibility of the institution, and skill development, the responsibility of industry.

An opposing view contends that graduates should be equipped with skills required to handle the latest technologies, if necessary, at the expense of basic skills. This school of thought maintains that since the market place is so competitive technologically, employers cannot afford expensive on-the-job training for graduates. To remain competitive, industry has to hire the best technologists who must be productive as soon as possible. While knowledge of subjects such as mathematics and sciences is an advantage (since problem-solving and analysis are increasingly being undertaken by computers), the necessity for technologists to focus on those subjects is diminished.

Some respondents were not prepared to align themselves with either position, suggesting that the individual needed to learn "how things work and how things tie together in a system," rather than having specific technological skills. The graduate must be able to determine quickly how information flows: who gets what information, who uses what information, what do they do with it, and why. The graduate must learn "how to learn," a basic skill not taught in schools and training colleges.

While not diminishing the importance of a specialized technical training, some respondents said that colleges are not producing enough "well-rounded" graduates. Liberal arts courses should be a required part of a technologist's training. The graduate must be able to communicate: to write a report and to make an effective presentation. Communication skills are important, not only because the technologist has to effectively get the information to others, but also because, in the interests of his own career, he has to be his own salesman.

QUALIFICATIONS OF TECHNOLOGY GRADUATES: THE GAPS

Specialized Skills

Most respondents said that new graduates are technically prepared for the work place, but only in a general or basic way. Many graduates lack company specific or specialized knowledge; however, the employer is often prepared to fill the gap with training or equipment orientation programs. In one "high tech" industry, new graduates receive ten to twelve weeks' training before they are allowed to touch the equipment. But there is a marked difference in expectations from one employer to another. Some employers who take on graduates who are 60 percent useful immediately think they are getting good value for money. Others expect their new recruits to be fully productive at once. The difference is often a function of the size, the policy and the product line of the employer.

Market demand and economic factors play a role too. If there is an oversupply of graduates, companies will be able to seek out the best and will be able to raise the hiring requirements. Similarly, if a company has time, it will provide training. However, the consensus among respondents is that most companies provide some level of in-house training of new graduates regardless of skills.

Communications Skills

When asked if graduates have the required skills, one respondent said,

"It depends on who you talk to." People dealing with systems and software are generally satisfied with new graduates as being "prepared in basic technology and numeracy" but not with those graduates' level of literacy. "Generally the standard of written and spoken English is not on a par with the technical skills." This sentiment was reiterated in a number of ways. Some pointed to a weakness in communication and interpersonal skills which is reflected in report writing, group work and project orientation. To other employers these abilities, which are of secondary importance, may develop with work experience since the technologist only "enters the learning curve after school."

Business Skills

A number of respondents would like to see technologists with a sense of the "bigger picture." Many new graduates are unversed in - or unaware of - the languages of finance, business, economics, sales and marketing. Knowledge is missing in such fundamentals of business as quality production, project evaluation and general profit and loss.

Other Gaps

Alberta employers, on the whole are satisfied with the level of technical competency of new graduates; however, several think that recent graduates have too little "hands-on" experience, having been taught theory at the expense of practical application. One respondent points out there is much more to being a good technologist than knowing

everything about a discipline. Graduates lack that "rounding out" of skills and abilities. Some believe that gaps in knowledge can be overcome if the right attitude to learning and work is present, while others say that such attitudinal training is beyond the scope of the technical institutions. Yet another asks, "Can common sense be taught?"

EXPERIENCED TECHNOLOGISTS – THE GAPS

Unlike their less experienced counterparts, experienced technologists tend to lack microelectronic and computer skills. In addition, their communication and project administration skills are often weak, although adeptness in the second case is often a function of the extent and diversity of their experience.

Many technologists have already been exposed to change in work place or work function because of either technological innovation or economic conditions. There is always a small percentage who have difficulty coping, but the majority do adjust. Citing an example in the aeronautical industry where some 200 draftspersons were required to switch from traditional drafting to CAD/CAM, one respondent explained that the transition was made smoothly despite the absence of electronic and computer knowledge, but training was crucial.

TRAINING

The theme that recurs throughout the interviews is that training is continuous, a life-time process. Most large employers undertake some training programs, either in technical, work or life skills, or simply basic company orientation. Where company growth has been retarded by adverse economic conditions, some companies are shifting employees from one position to another rather than hiring new employees. In other companies one role has been expanded to incorporate another. Training and retraining in these situations has increased.

Companies are also contracting training to specialist and consultant groups. In many cases, the vendors or suppliers of technical equipment offer a training program to the purchaser or lessee. Some larger firms encourage the technologist to undertake his own training through evening or correspondence courses and then share the cost of the fees. The consensus is that training is expensive. Smaller companies or those susceptible to economic hiccoughs cannot afford to undertake training.

"High-tech" companies expect to finance training because of the changeable nature of their industry. One respondent in telecommunications estimates that every employee in his company receives direct training for two or more weeks a year. That same employer believes that the average technologist is not fully proficient until he or she has been with the company for 18 months. Another company arranges a week-long Kepner-Tregoe problem-solving course for each of its technical employees.

Life and work skill training have become popular with larger companies too. Courses and seminars in health and safety regulations and practices, group dynamics, team leadership, communications and assertiveness are regularly sponsored or provided by large employers. However, such training may be the first to be trimmed in times of economic stress.

Technical institutions are attempting to expand further into customized courses at the post-graduate level, but it is generally acknowledged that these institutions cannot undertake specialized training by themselves. They do not have the funds and the latest technical equipment in the industrial workplace. As a result, colleges cannot be in the vanguard of technological change, but must respond to industry's need.

Industry does not always recognize or acknowledge the need for training, and this is one of the hurdles to be overcome. Another is the cost of training. Seminars do not often communicate a lot of in-depth information and they are expensive. More economical ways of training must be identified, particularly in light of the observation that some 80 percent of the people who will be in the labour force in 1990 are already in the work force today. Given the changing nature of technology, the economic conditions and the short life expectancy of a technologist's skills, this observation indicates that training itself could become an important industry.

PREPARING TECHNOLOGISTS – ACTIONS BY INSTITUTIONS

Institutions are faced with the difficult challenge of meeting industry's technical manpower needs. To ensure these needs are adequately met, business and industry can liaise through technical advisory committees or joint working committees which represent both groups. Such committees must meet regularly and often to review and evaluate curricula and to determine whether the institutions' objectives and messages are effective. The comment was made that the institutions are perhaps turning out a product without having done extensive market research. An Alberta respondent suggested that there is a tendency to add new courses without cutting the old ones.

One respondent observed that, in Ontario, some technical colleges are moving closer towards the university style in providing more theoretical or academic courses and less "hands-on" applications. As a result, the gap between industry and these colleges is widening. Advisory committees could help to alleviate such a movement which is ultimately detrimental to the students.

The co-operative (co-op) work program is supported by many respondents as providing a bridge between the educational institutions and the workplace. "The technologist's attitude to learning is changed by the work experience, and the instructors are kept on their toes." A co-op program helps keep the theoretical side of technology in perspective while giving the student practical exposure to high technology equipment. However, Alberta respondents were quick to point out that such a program is difficult to introduce or maintain in

uncertain economic times. Furthermore, some technologists are insufficiently trained to go into the industry after having completed only a portion of their course work.

Centres of Excellence likewise help to ensure that industry's needs are met by institutions. Such centres offer post-graduate level seminars and short courses with state-of-the-art technical equipment and specialized instructors seconded from industry. (The Centre for Advanced Technology Education or CATE is an example. Refer to Appendix E.) Another advantage to these centres is that they offer "a modular approach to education with smaller bite-size chunks giving the students an opportunity to choose courses packaged to their individual needs."

Having identified gaps in communication skills, interpersonal relations and business understanding, respondents recommended that institutions offer appropriate courses to close these gaps. Several mentioned the method of course/program delivery as being in need of adjustment. Institutions still use classroom-based instruction and all entrants receive similar treatment. Customized learning packages or computer-aided learning provide an alternative.

Acknowledging that systems technology requires special training, respondents posed the questions: on which disciplines do the technologists concentrate, and can they acquire more training without extending the length of their academic program? A systems approach is difficult to teach in the classroom because of its diverse multi-disciplinary and unstructured nature. Colleges and training institutions

can bridge the gap between disciplines by helping the student "learn how to learn." Training must be such that, once away from a structured environment, in a noisy and distracting atmosphere, faced with solving a problem that does not appear in a textbook, the student will know how to apply himself. The most employable technologist will be the one with training in the right mix of disciplines and the common sense to apply his knowledge. The strongest technical schools will be those offering courses of an interdisciplinary mix which can be altered to keep up to date with industry demand.

While the trend moves towards interdisciplinary knowledge, no one can be expected to be the "seer and knower of all things." The new technologies are therefore leading to structural changes in the work place: organizational structure is becoming more horizontal; problem identification, analyses and resolution are increasingly being undertaken by a team. More emphasis is being placed on worker participation, quality work circles and participative management practices. Accompanying this increase is a call for "more rounded" technologists, those with interactive, interpersonal and communication skills. Some respondents maintain that the best technologists also have an understanding of their employer's operation – from the production line to sales and customer relations, and that technologists will increasingly need to understand customer requirements and sales techniques. The successful technologist will require not only an appropriate mix of technical training, but also a broader perspective on company procedures and strong interpersonal skills.

PART 3 THE TECHNOLOGIST'S PERSPECTIVE

INTRODUCTION

Once management has made the decision to introduce new technology, it is the employee who must adapt to the different equipment or the changed environment. The new technologies have a most direct and immediate effect on technologists. Sometimes that effect can be negative and result in unemployment. In other cases, the technologist may require special training or further education to cope with a change.

ASET members may be directly affected by technological change in the workplace. How many have experienced technological change? How well equipped are they to handle such a change? Has their formal technical education proven adequate, or do they require specialized training on the shop floor? How much training is provided by the employer, and how much do technologists rely on their own initiative to upgrade their skills?

In an attempt to answer these and similar questions, a questionnaire was designed and distributed to those ASET members attending chapter meetings. A total of 159 members completed a questionnaire representing four percent of ASET membership. Selected findings from that questionnaire are reported in this part of the study.

OBSERVATIONS AND RESULTS

The responses to the membership questionnaire lend support to the comments made in Part 2 of this study. The major and relevant findings are highlighted below.

Technological Life Expectancy

- Seventy-two percent of the participants reported a change in discipline or work function during their career. Of these, 20% attributed the change to economic conditions and 9% attributed the change to the introduction of new technology.

- Fifty-three percent of those experiencing change underwent retraining, either provided by the employer on-the-job or through self-directed studies.

Adequacy of Education

- ASET members strongly believe that their post-secondary education adequately prepared them for the workplace. (84% agreed that their post-secondary education was "helpful and relevant.")

- Sixty-seven percent of participants received on-the-job training in their first job following graduation. Of these, 62% did so because of the specialized nature of the work and 44% did so because of company policy.

Gaps

- Forty-two percent would like to see institutions emphasize the teaching of communication skills, 30% would like to see increased emphasis on basic technical courses and supervisory skills.

Future Impact of Technology

- Fifty-five percent of the participants expect that the new technologies will affect their careers over the next 5 years. Forty-five percent of these identified computer technology as having the greatest impact.

- Twenty-eight percent of the participants expect to undertake computer-related training over the next 5 years.

In addition, members made the following comments:

- We need more practical problem-solving and more on-site study (in our educational courses).

- Rapid technological change has made much of my education obsolete, however the basics are still relevant. (Graduate of 1978)

- Technical training combined with on-the-job training is sufficient.

- Would like to see continuing education courses at Lethbridge Community College (LCC), similar to those at N.A.I.T. and S.A.I.T.

- Rate of technological change is faster than bureaucratic decision-making so how can we keep up? (Government employee)

PART 4 SUMMARY AND MAJOR FINDINGS

SUMMARY

Technological Change

- the widespread diffusion of the microprocessor some 12 years ago has led to significant technological change

- over the next five years, microelectronics applications will continue to be linked to the greatest number of changes

- the process of technological change - invention, innovation and diffusion - is market-driven and can be protracted

- innovations are becoming increasingly interdependent

- technological changes are predicted to be evolutionary and incremental occurring most often in concert with other changes such as those in work organization

- as the workplace changes in response to new technology so does the method of tackling work: team projects and quality work circles are predicted to become prevalent

- the nature of work and work functions is changing so substantially that the "technological life expectancy" of a new graduate may be as little as five years. Consequently, training and re-training is becoming an integral part of the technologist's career.

- specific innovations identified as having the most impact on Canadian technology include robotics, lasers, CAD/CAM, fibre optics and computers. In Alberta, the emphasis in on lasers, fibre optics (in communications), computers and Computer Aided Drafting and Design (CADD)

- a number of principal work functions are predicted to increase in scope and importance, namely, CADD, plant and industrial operations, quality control and assurance, process and product development, project administration, research and development, marketing and sales, and education.

- Perceived high growth disciplines include instrumentation technology, electronics, communications/telecommunications technology and computer technology.

The Canadian Perspective

- Characterized by a resource-based economy, Canada is facing the prospect of weak world markets over the near term.

- Canada is lagging in international competition and there is every indication that this is due to a slow rate of innovation and diffusion.

- some of the reasons for this lag include: market size and competition, firm size, foreign ownership, government policy, attitudes to change, and education.

Implications for the Technologist

- the interdependency of innovations means that there will be a growing demand for technologists with skills in more than one discipline and for those who understand the relationship between the components of a system

- fundamental to the microprocessor revolution and the systems approach is a knowledge of computer applications

- changes in the workplace require the successful technologist to possess a flexible attitude and strong interpersonal and communication skills, and those attributes are over and above technical competency. Ideally the technologist will also have a basic understanding of business fundamentals.

Implications for Institutions

- business and industry advocate strengthening links with educational institutions through advisory committees, co-operative work programs and centres of excellence.

- graduating technologists and employers alike identify gaps in education as existing in communication skills, interpersonal relations and business understanding.

- basic to the systems approach is a need for the student to "learn how to learn" and to understand the relationship between the components of a system.

- the strongest technical schools will be those offering courses of an interdisciplinary mix which can be altered to keep up to date with industry demands.

MAJOR FINDINGS

- over the next five years, microelectronics applications will be linked to the greatest number of changes with developments predicted to proceed in an extrapolation of what now exists

- technological changes are expected to be evolutionary and incremental occurring most often in concert with other changes such as those in work organization

- the major trend is towards technological change of an inter-related nature with innovations becoming increasingly interdependent; change will not often occur in isolation.

- emanating from this trend is an increased demand for an interdisciplinary and systems approach to work applications

- the result is predicted to be a demand for technologists with skills in related disciplines.

- the challenge of technologists will be to see and understand the components of the whole system and to keep that system operating effectively, with the role of the troubleshooter becoming an important one

- computer literacy is stressed not so much for its own sake as in the context of the systems approach and as a means to understanding logic

- as the workplace changes in response to new technology so does the method of tackling work; team projects and quality work circles are predicted to become prevalent

- success in such a work milieu will depend on the technologist's possessing a flexible attitude and strong interpersonal and communication skills; technologists will have to be able to work across discipline lines and across organizational lines.

- the leading technologist will also have a sense of the "bigger picture" of business, including a basic knowledge of finance, economics and marketing

- the nature of work and work functions is changing so substantially that the "technological life expectancy" of a new graduate is as little as five years

- continuous learning is becoming a reality since the technologist may be required to "re-tool" three or four times in his working life to keep abreast of the changing technologies

PART 5 RECOMMENDATIONS AND IMPLICATIONS

RECOMMENDATIONS FOR ASET MEMBERS

The issues identified in this report are ones that may well mean the difference between being hired or not being hired, being promoted or passed over, or being kept on and being laid off. They are critical to ongoing employability. While there are no guarantees - particularly in difficult economic times - following these recommendations will significantly improve your odds of successfully and readily adapting to technological and other changes.

- Assume full responsibility for your career development, for assessing change and for adapting accordingly, even though it might be argued that the government, the educational institutions and your employer have some responsibility. Utilize fully the resources available through your employer, your association, government and the institutions.

- Examine your present job critically. Keep aware of changing technology. The product or process with which you are working could be eclipsed by new technology. This examination should be done yearly.

- Keep up to date on technological changes in your field. Two things happen if you don't keep up - you become out of date technically and more susceptible to lay off and you lose the ability to adapt to future change.

- Examine the disciplines that are or might be related to your

discipline and take steps to acquire more knowledge here. Your value to your employer and your marketability will improve significantly.

- Use the comments on work functions in this study as a cross check in relation to your situation, keeping in mind that work functions often cross discipline boundaries.

- Improve your communications skills (oral and written) and your interpersonal skills. Respondents were nearly unanimous in the view that promotability depends heavily on these skills. More and more you will be required to communicate and work across discipline lines and across organizational lines. Improving one's skills in these areas will, furthermore, take more than a crash course in the subject. It may well take a combination of courses and applied knowledge over a period of time.

- Acquire or expand your knowledge of microelectronics systems and applications related to your field of work. This is the most pervasive of the technological changes likely to affect the workplace. The key is to understand the applications to your work not necessarily to become a microelectronics expert.

- Be aware of the importance that employers place on motivation, enthusiasm, creativity and hard work. These attributes can overcome or neutralize deficiencies that you have in other areas. They will greatly increase your resistance to lay off.

IMPLICATIONS FOR POST-SECONDARY EDUCATIONAL INSTITUTIONS

The implications from the findings of this study indicate the following courses of action by education institutions:

- Continue to improve responsiveness to the needs of employers by:
  - broadening employer input to curriculum decisions
  - expanding student opportunities to continuing education programs
  - establishing centres of excellence for advanced post-diploma study.
  - introducing or expanding student co-operative work programs
- Increase the priority given to improving communication skills and interpersonal skills. These are critical to the mobility and promotability of the graduates.
- Re-examine effectiveness in preparing graduates for the workplace, especially in:
  - economic environment
  - attitude and motivation
  - business/industry orientation
  - their knowledge of the learning process – "learning how to learn"
- Investigate interdisciplinary options in terms of scope, feasibility and marketability.

- Investigate the feasibility of more systems orientation in the teaching of the engineering technology disciplines.

- Foster a basic understanding of microelectronics - systems and applications – in all disciplines. Ensure adequate access to the subject in continuing education.

- Verify respondents' perceptions that the high growth disciplines will be electronics technology, communications/telecommunications, instrumentation and computer technology, and make appropriate adjustments.

- A complete market analysis by discipline may be required to determine the direction of each discipline and the underlying factors influencing skill requirements and growth. Combined with an examination of work functions such an analysis could lead to a comprehensive understanding of interdisciplinary implications and job functions such as systems analysis, evaluation, problem solving and trouble shooting.

- Interestingly, the role of the institutions in retraining was seldom mentioned despite the existence of continuing education programs. There may be a number of reasons for this. In some cases the institutions are regarded primarily as the providers of basic education, in other cases equipment suppliers provide technical training - especially for new equipment ("The requirements are too specialized for the institutions"). Large firms typically have extensive training programs. There may also be a lack of awareness of the courses available through the institutions. An opportunity for increasing the scope of continuing education programs may exist, particularly courses such as communications, supervision and computer familiarization.

ISSUES FOR FURTHER ANALYSIS BY THE INSTITUTIONS

- In an environment of technological change and economic uncertainty with the prospect of declining enrollment, a full analysis of the market and the development of comprehensive marketing strategies may be prudent. Analysis should include market size and profile, competition in the marketplace, and strengths and weaknesses of the institution, and should lead to the development of specific goals, objectives and strategies. While many of the institutions have taken steps in this direction a more comprehensive approach may be required to ensure ongoing viability.

OTHER ISSUES

- The question of a more competitive environment for the educational institutions raises an important question in regard to public funding. Will increased competition between institutions (public and private) result in better overall performance - producing graduates that are both better suited to the needs of industry and better equipped to handle change? On the other hand, will increased competition merely result in overlapping and duplicated curriculum and the inefficient use of resources? Should not the institutions co-operate more instead of competing? The Department of Advanced Education might well examine this issue.

- The terms of reference of this project did not include reference to the role and responsibility of employers yet there are a number of implications evident throughout this report. Many employers provide extensive training for their employees, others cannot afford it. Many work closely with the institutions yet more

dialogue is often indicated. These and similar questions indicate a need for further analysis of the role and responsibilities of employers and their interaction with the institutions.

CONCLUDING COMMENT

This study has focussed on a relatively new area of technological change - the impact of change on the technologist. While specific technological innovations will continue to affect the technologist, it is the impact of these changes in combination together with changes in the way work is performed that will have the biggest impact. The implications for both the technologists and the institutions are far reaching. While both ASET members and the institutions have been addressing many of these issues - and in that sense they are not entirely new - the evidence suggests that not nearly enough is being done or that what is being done is not as effective as it might be. Both groups should consider the recommendations in this context.

APPENDIX A

DETAILED OBJECTIVES OF THE STUDY

OBJECTIVES

TECHNOLOGICAL CHANGE STUDY

To determine the impact of future technological changes and other factors which will influence the career path and required skills of Engineering Technologists by:

i) Identifying for Engineering Technologists the possible changes in demand for job skills (knowledge and practice) which will be caused by the rapidly advancing technological changes in the working environment.

ii) Recommending courses of study which may be required by Technologists so that they may maintain currency of skills and knowledge.

iii) Identifying and recommending means whereby Technologists may upgrade their skills with minimal disruption to:

   a) current employment, and
   b) economic status

iv) Identifying trends in consumer demand

   a) regionally
   b) nationally, and
   c) internationally.

(Forecast period – approximately 5 years)

APPENDIX B

LIST OF ALBERTA INTERVIEWS

LIST OF EASTERN CANADA INTERVIEWS

ALBERTA INTERVIEWS

Peter T. Ambrose, P.Eng.
Director, Project Development
Syncrude Canada Ltd.
Edmonton

Norman L. Arrison,
Ph.D., P.Eng., President
The Alberta Laser Institute
Edmonton

Brian Barge, Ph. D.
Department Head
Advanced Technologies Dept.
Alberta Research Council
Calgary

D.J. (Dave) Cornies
Manager,
Technical Services
NOVA, An Alberta Corporation
Edmonton

W.D. (Bill) Croft
President
Calgary Research &
Development Authority
Calgary

Dow Chemical Canada Inc.
Fort Saskatchewan
Gordon Griffin
Karl Jegodtka
John MacLaughlan
Carl MacLean
Darrell Debenham

Glenn C.M. Derbowka
Director, Technology and
Professional Development
Petro-Canada Resources
Calgary

Allan P. Gannon
Acting Vice President
Westerra Inst. of Tech.
Stony Plain

William H. Glanville
Chairman, Civil and Arch.
Technologists - N.A.I.T.
Edmonton

B. Heemsbergen, Ph.D.
Executive Director
Alberta Advanced Education
Edmonton

John D.F. Hendershot, P.Eng.
Engineering Manager
Esso Petroleum Canada
Edmonton

Alex Hittel, C.L.S., P.Eng.
Chief Executive Officer
Nortech Surveys (Canada)
Calgary

Rupert Hooper, P.Eng.
Supervising Engineer
Pipeline Engineering (Design)
NOVA, An Alberta Corporation
Calgary

J.F. Hugo, P.Eng.
Manager of Drainage
The City of Edmonton
Edmonton

T.J. Ingraham, P.Eng., C.L.S.
Special Projects Engineer
Alberta Environment
Edmonton

Dave Klapstein
Business Network Planning
Alberta Government
Telephones, Edmonton

G.J. Lauzon, M.D. Ph.D.
Vice-President Scientific &
Regulatory Affairs
CHEMBIOMED Ltd., Edmonton

Chow Lee
Dean of Academic Affairs
DeVry Institute of Technology
Calgary

Ken Low
President, Calgary Advanced
Technology Association
Calgary

A.B. Maurer, P.Eng.
City Engineer, Transportation
The City of Edmonton
Edmonton

Doug McCutcheon
Employment & Placement Manager
Dow Chemical Canada Inc.
Fort Saskatchewan

George B. Miller
Pres.and Dir. of Research
NOVA Husky Research Corp.
Calgary

Karl Miller
Manager - Corporate Relations
Alberta Microelectronic Centre
Edmonton

Robert G. Miller, MS, P.Eng
Director, Planning & Applied
Research, Southern Alberta
Institute of Technology
Calgary

Jim Milton
Business Network Planning
Alberta Government Telephones
Edmonton

G.A. Mitchell, B.Sc., MBA
General Manager, Edmonton
Research & Development
Park Authority, Edmonton

Andre Morin, P.Eng.
Vice-President
Engineering & Construction
Alberta Power Limited
Edmonton

C. Nakamura
Manager, Engineering Dept.
The City of Calgary
Calgary

Walter Nieboer, P.Eng.
Vice-President, Engineering
TransAlta Utilities Corp.
Calgary

B.E. Novak, P.Eng.
Vice President
Stanley Associates
Engineering Ltd.
Edmonton

Don B. Ogaranko
Director
Alberta Manpower
Edmonton

Takashi Ohki
Assistant Director
Alberta Economic Development
Edmonton

Art Olson, Ph.D.
Assistant Deputy Minister
Alberta Agriculture
Edmonton

L.M. (Larry) Perpar
Employee Relations
Co-ordinator
Dow Chemical Canada Inc.
Fort Saskatchewan

Gordon Politeski
President
Biomira Inc.
Edmonton

G.W. Seale, B.A.Sc., P.Eng.
Manager,
App. Res. & Development
Southern Alberta Institute
of Technology, Calgary

Grant Serink, P.Eng.
Engineering Manager
Alberta Microelectronic Centre
Edmonton

Paul L. Strohschein
B.Sc. M.Ed. P.Eng.
Dean - Engineering
Technology
Northern Alberta Institute
of Technology, Edmonton

Brian Sullivan, Ph.D.
Assistant Deputy Minister
Alberta Economic Development
Edmonton

Gerard Tertzakian, Ph.D.
President
Raylo Chemicals
Edmonton

Lorne R. Tetarenko
Department Head
Southern Alberta Institute
of Technology, Calgary

Ian L. Wellman, P.Eng.
Manager
Calgary Research &
Development Authority
Calgary

Rick White
Manager VLSI Design
NovAtel Communications Ltd.
Calgary

EASTERN CANADA INTERVIEWS

P. Berthiaume
Assistant Chief Technical Research
Technical Research Centre
C.N.
Saint Laurent

L. J. Boisvert
Director, Network Services
Network Services
Telesat Canada
Ottawa

Stanley But
Senior Economist
Manpower Studies Group
Ontario Manpower Commission
Toronto

Ron D. Clarke
Manager
Network Services
Telesat Canada
Ottawa

Arthur J. Cordell
Science Adviser
Science Council of Canada
Ottawa

Germain Denis
Deputy Head
Multilateral Trade Negotiations
Ottawa

F. C. Devlin
Manager
Technical Administration-Operations
Telesat Canada
Ottawa

Andrew Falconar
Personnel Manager
Pulp and Paper Research
Institute of Canada
Pointe Claire

John Farrell
President
Business Group
Bell Canada
Ottawa

Cy Flacks, M.Sc., P.Eng.
Dean of Technology
Seneca College of Applied
Arts and Technology
Willowdale

Doug Giddings
Labour Market Outlook and
Structural Analysis - Supply
Employment and Immigration Canada
Ottawa

William Gilles
Special Assistant to the Chief
Executive Officer
Canadian Labour Market and
Productivity Centre
Ottawa

B. B. "Ike" Goodfellow, P.Eng.
Managing Director
Centre for Advanced
Technology Education
Ryerson Polytechnical Institute
Toronto

E. T. Grunberg
Assistant Vice-President
Technology
Northern Telecom Limited
Mississauga

Mr. Bob Kartzmark
Operations Manager
Research Division
Esso Petroleum
Sarnia

Robert J. Kavanagh, Director
Research Manpower Programs
Natural Sciences and
Engineering Research
Council of Canada
Ottawa

George J. V. Kokich
Labour Market Outlook & Structural
Analysis Strategic Policy & Planning
Employment and Immigration Canada
Ottawa/Hull

Karl L. Mayer
Vice-President, Technology
Ontario Centre for
Microelectronics
Ottawa

Ian MacDonald, P.Eng., Chairman
Mechanical Technology Department
Industrial, Mechanical,
Aerospace, Metallurgy
Ryerson Polytechnical Institute
Toronto

Keith Newton
Director
Labour Market Group
Economic Council of Canada
Ottawa

Richard Parker, M.Sc.
Chairman
Electronics Engineering Technology
Seneca College of Applied Arts
and Technology
North York

S. Rao
Economic Council of Canada
Ottawa

J. Scrimgeour, P. Eng.
Senior Advisor
Department of Electrical Engineering
National Research Council of Canada
Ottawa

Juri Silmberg, M.A.Sc.,
P.Eng., Chairman
Faculty of Technology
Ryerson Polytechnical Inst.
Toronto

Jean-Pascal Souque
Science Adviser
Science Council of Canada
Ottawa

Guy Stead
Science Council of Canada
Ottawa

Keith M. Thompson, Sc.D.
Director
Economics and Planning Division
Pulp and Paper Research
Institute of Canada
Pointe Claire

Clifford N. Tite, P.Eng.
Manufacturing Engineering
Technology Department
Algonquin College
Ottawa

APPENDIX C

STRUCTURED INTERVIEW OUTLINE

ALBERTA SOCIETY OF ENGINEERING TECHNOLOGISTS
STRUCTURAL INTERVIEW OUTLINE

1. Looking broadly at the question of technological change, a number of informed people feel that change over the foreseeable future will occur as a result of advances in the use of:

   - microelectronics
   - biotechnology
   - materials technology (eg. ceramic engines in automobiles)

   What is your feeling about the accuracy of this statement? Globally? Specifically?

   What other technological changes would you add to this list? Would you subtract any?

2. From the following list of technological innovations would you please comment on (a) the recent impact of each innovation on your organization, sector or field of knowledge and (b) the anticipated impact over the next 5 years?

   - robotics
   - lasers
   - CAD/CAM
   - fiberoptics
   - artificial intelligence
   - communications (telecom.)
   - high pressure fluids (cutting, mining, drilling)
   - computers (high speed, mini)
   - more combinations of the above, more interdisciplinary approaches to problems/ opportunities
   - other

   Check List of Impact

   - efficiency
   - cost reduction
   - longer production runs
   - manpower
     - redundancies
     - shortage of trained personnel
   - job skills
   - retraining
   - other

3. A listing of work functions is attached. In which areas do you anticipate an increase in demand? Which do you see decreasing in demand? Which will stay about the same?

   Why do you feel this way?
   (Technological change? Economic circumstances? Other?)

4. Looking specifically at the engineering disciplines (included in this package) which fields do you see increasing in demand? Which do you see decreasing? Which will be fairly constant?

   Why do you feel this way?

5. What skills do you feel will be important for technicians and technologists in terms of:

   - technical skills
   - life or work skills
   - other?

6. a. Do you feel that recent graduates have these skills? If not please comment on any gaps.

   b. Do you feel that experienced people have these skills? If not please comment on any gaps?

7. In house training is becoming a more topical subject both for recent technology graduates and later in their career.

   What observations would you make with regard to;

   - availability of in-house training
   - any trends in training; re-training
   - reasons for training, re-training
   - frequency.

8. What actions should educational institutions be taking to better prepare technology graduates for the work force?

Other Questions Specific to Employers of Technicians and Technologists

1. Approximately how many engineers are there in your organization? How many technicians and technologists? What percentage are they of the total organization?

Engineers	_____	Percentage	_____
Technicians	_____	Percentage	_____
Technologists	_____	Percentage	_____

2. Have your technicians or technologists changed disciplines since they have been employed by you?

   Frequency

   Numbers

   Identifiable trends? (From _____ to _____)

   Main reasons?

3. Where do you find the manpower to meet your demands?

   - from other companies?
   - from technical institutions?
   - through retraining?

   How satisfactory are these sources in meeting your demands?

   Have you laid off technicians or technologists in the past few years? How many? Why (economic circumstances, technological change?)

4. Other Comments?

PRINCIPAL WORK FUNCTIONS

a. Drafting, design and design modification.

b. Equipment installation, maintenance and servicing.

c. Facilities inspection and maintenance.

d. Plant & industrial operation/production.

e. Quality control & quality assurance.

f. Standards inspection/Regulatory investigation.

g. Process/Product development.

h. Surveying.

i. Project administration.

j. Research & development

k. Marketing and sales.

l. Management.

m. Education/Teaching.

n. Other, specify: .....

.....

ALBERTA SOCIETY OF ENGINEERING TECHNOLOGISTS (ASET)

ASET is the professional Society representing the Engineering Technicians and Technologists in Alberta. It has a membership of approximately 5600. The membership distribution of ASET is as follows:

	Percentage of Membership 1985
CIVIL	16.1%
ELECTRICAL	9.9%
ELECTRONICS	9.0%
MECHANICAL	8.4%
PETROLEUM	8.9%
DRAFTING/PIPING	8.1%
INSTRUMENTATION	4.1%
CONSTRUCTION	3.4%
ARCHITECTURAL	2.7%
CHEMICAL	2.5%
GAS/HYDROCARBON	2.3%
SURVEY	2.1%
COMMUNICATION/TELECOM	1.6%
AIR COND. & REFRIG.	1.8%
GEOLOGICAL TECH.	1.4%
	82.3%
OTHER	17.7%
	100.0%

APPENDIX D

ASET MEMBER QUESTIONNAIRE

CONFIDENTIAL

ASET MEMBER QUESTIONNAIRE

IMPACT OF TECHNOLOGICAL CHANGE

1. EDUCATION AND CERTIFICATION

- Graduate of (name of Institute) .....
- Technician ..... or Technologist ..... (check one)
- Year of Graduation .....
- Length of time in Present Job ..... years.
- Employed by .....Approx. No.of Employees .....

2. A. MAJOR ENGINEERING TECHNOLOGY DISCIPLINES

Please check(✓) the major engineering technology discipline(s)in which you have a post secondary education and/or work experience and length of experience.

		Work Experience			
		Post Sec. Education	Most recent or current	Second last exp	Third last experience
a.	Civil	☐	☐	☐	☐
b.	Mechanical	☐	☐	☐	☐
c.	Electrical	☐	☐	☐	☐
d.	Electronics/Computer	☐	☐	☐	☐
e.	Chemical	☐	☐	☐	☐
f.	Mineral Resources/ Metallurgy	☐	☐	☐	☐
g.	Industrial	☐	☐	☐	☐
h.	Environmental/ Geosciences	☐	☐	☐	☐
i.	Biological/Biomedical	☐	☐	☐	☐
j.	Other, specify				

. . . . . .

2. B. PRINCIPAL WORK FUNCTIONS

Please check (✓) the principal work function(s) in which you have worked.

		Experience: Principal Work Functions		
		Most Recent	Second last	Third last
a.	Drafting, design and design modification.	☐	☐	☐
b.	Equipment installation, maintenance and servicing.	☐	☐	☐
c.	Facilities inspection and maintenance.	☐	☐	☐
d.	Plant & industrial operation/ production.	☐	☐	☐
e.	Quality control & quality assurance.	☐	☐	☐
f.	Standards inspection/Regulatory investigation.	☐	☐	☐
g.	Process/Product development.	☐	☐	☐
h.	Surveying.	☐	☐	☐
i.	Project administration.	☐	☐	☐
j.	Research & development.	☐	☐	☐
k.	Marketing and sales.	☐	☐	☐
l.	Management.	☐	☐	☐
m.	Education/Teaching.	☐	☐	☐
n.	Other, specify:			
	. . . . .			

2. C. If your response to "A" or "B" above indicates a change in discipline or work function over your career please indicate why you changed.

- More interesting position ..... ☐
- Promotion ..... ☐
- Forced Change Due to:
  - Introduction of new Technology ..... ☐
  - Financial Circumstances of Employer ..... ☐
  - Being Laid off ..... ☐
- Other (please specify) .....

.....

Comments:

.....

.....

.....

D. Did you undertake any retraining as a result of these changes?

Yes: ☐ No: ☐

If yes, please comment on subjects covered:

.....

.....

Where held: .....

Length of course (courses) .....

.....

3. PRINCIPAL WORK SECTORS/INDUSTRIALLY RELEVANT AREAS

Please check( ) principal work sectors or industries in which you have worked:

	Work Sector/Industry Experience		
	Most Recent	Second last	Third last
a. Fossil Fuel Resources, crude oil, natural gas, oil sands, heavy oil, coal:			
i) Primary production -	☐	☐	☐
ii) Processing including Chemical products -	☐	☐	☐
b. Agriculture			
i) Primary production -	☐	☐	☐
ii) Secondary industry -	☐	☐	☐
c. Mineral resources/mining	☐	☐	☐
d. Forestry and logging	☐	☐	☐
e. Fisheries	☐	☐	☐
f. Construction and municipal sector	☐	☐	☐
g. Transportation sector	☐	☐	☐
h. Energy sector (other) electric power generation, transmission industrial power, oil and gas pipelines	☐	☐	☐
i. Environmental engineering and geosciences	☐	☐	☐
j. Communications, electronics and control systems	☐	☐	☐
k. Manufacturing sector	☐	☐	☐

l. Other: (please specify) .....

.....

4. On your first job after post secondary education,

a) Did you receive on-the-job training
yes ☐ no ☐

b) if yes, approximate percentage of time; . . . %

c) if yes, what was the main reason for the training?

- specialized job requirements ☐
- post secondary education was inadequate ☐
- company/employer policy ☐
- changed discipline ☐
- Other (please specify) .....

.....

5. I found that my post secondary education was particularly helpful and relevant when I started work (check one of the following)

Strongly agree . . . . . ; agree . . . . .; mildly disagree . . . . . strongly disagree . . . . . .

With respect to job entry preparation I would like to see more emphasis in the post secondary institutions on;

- Foundation courses (eg. math, physics, chemistry) . . ☐
- Basic Technical Courses . . . . . ☐
- Communication Skills (writing, speaking) . . . . . ☐
- Supervisory skills. . . . . ☐

Other (please specify) . . . . . ☐

None, the courses are satisfactory . . . . . ☐

6. There are many factors that influence our jobs and our careers - some of them related to technological change, some of them related to general economic conditions and some related to personal preference, ambition. How do you feel about the following statements?

My job/career has not been affected much over the past several years (please check one). Do you strongly agree? . . .; agree . . . .; mildly disagree . . . . .; strongly disagree . . . . .

7. If your job or career has been affected over the past few years, was the main factor economic ☐ ; new technology ☐ ; personal desire to change ☐ ;
Other (please specify) . . . . . .

. . . . . .

8. Looking forward over about the next five years what technological changes might be implemented that would directly affect your job or career?

- Probably none . .
- The following: . . . . . .

. . . . . .

9. What do you expect your requirements for ongoing career training will be in the next 3 to 5 years?

a) Technical training . . . . . .

. . . . . .

. . . . . .

b) Other training (eg. supervision, business) . . . . . .

. . . . . .

. . . . . .

10. Additional Comments:

(Please feel free to comment on any aspect of Technological change or educational requirements.)

. . . . . .

. . . . . .

. . . . . .

NAME (Optional) . . . . . .

APPENDIX E

AN INTRODUCTION TO CATE

An Introduction to CATE

Increased productivity. Reduced overheads. Lower inventories. Improved quality and service. This list of benefits and testimonials heralding the success of technological implementation in manufacturing goes on and on. Yet, in spite of the excitement it generates, in spite of its notable successes, for most manufacturers—both big and small—the application of advanced technology remains an intimidating prospect.

CATE brings advanced technology into a real-world perspective. Each of its seminars, from CIM: A Management Perspective, to Laser Applications, builds on the driving force behind all of the benefits realized through advanced technology: that is, the singular goal of improved customer service.

For some businesses, this goal may translate into a massive conversion of facilities, or the extension of existing facilities, to create a fully integrated, computerized environment. For others, it may mean the introduction of a single computer-based function which could mark the beginning of a long-range plan for computer integration. CATE recognizes these varying goals through programming that extends far beyond a generalist's approach to advanced technology theory—to include a consistent acknowledgement of the various "state-of-the-industry" factors which influence the success of technological applications.

Several factors join in enabling CATE to present the balance of technical and management issues necessary to generate imaginative applications in the workplace:

- A formal partnership with leaders in the field of advanced technology application, IBM Canada Ltd., Northern Telecom Limited, and Hewlett-Packard (Canada) Ltd.
- Faculty with an average of 15 years' industry experience, many of whom are currently practising in their fields.
- The secondment of full-time industry practitioners to CATE faculty and program development teams.
- Extensive state-of-the-art equipment enabling participants to enjoy hands-on experience in limited-enrolment seminars.
- Ongoing participation of an external advisory board comprising recognized experts from business, industry, government, and education.
- The continual refinement of programming through formal participant evaluations.

Fall 1985 brings the opening of the new CATE training centre. Comprising over 70,000 square feet of laboratory, classroom, and office space in downtown Toronto, the new centre features:

- 12 graphics terminals.
- 28 personal computers connectable to mainframe.
- 28 mainframe terminals.
- IBM 4381, HP 1000, HP 3000.
- CNC machining centres.
- A variety of industrial robots.
- Several operational software packages.
- Wide complement of electronic and light measurement equipment.
- Vision system.
- A fully equipped lecture theatre.

These facilities join to ensure that participants enjoy the full benefits of an optimum learning environment.

Published July, 1985
Ryerson Polytechnical Institute
Member: Council of Ontario Universities (C.O.U.)
Association of Commonwealth Universities (A.C.U.)

Ryerson's Centre for Advanced Technology Education is made possible by a grant from the Canada Employment and Immigration Commission Federal Provincial Skills Growth Fund, and the generous support of IBM Canada Ltd., Northern Telecom Limited and Hewlett-Packard (Canada) Ltd.